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THE PROBLEM OF THREE BODIES.

F. R. MOULTON.*

One of the most celebrated problems of mathematics is that of determining the motion of three bodies which attract one another according to the Newtonian law of gravitation. Nearly all of the great mathematicians from Newton to the present time have bestowed upon it their profoundest meditations. Its literature contains memoirs by Euler, Lagrange, Laplace, Poisson, Gauss, Jacobi, Cauchy, Delaunay, Adams, Weierstrass, Poincaré and Darwin, to mention only a few of those who have attempted to penetrate the recondite regions which it includes. These names call to mind many of the finest achievements in mathematics, and the fact that they are all attached to investigations in the same domain proves at once its importance and its difficulty.

The problem of three bodies is of great importance because it is a first step toward the problem of the motions of the members of the solar system under their mutual attractions. The sun, earth, and moon offer an example on which enormous labor has been bestowed; the sun, Jupiter, and Saturn present an example which must be treated by different methods; and triple stars having comparable masses constitute still another case. There are reasons which are obvious to one interested in astronomy why we should be able to predict the positions of the members of the solar system. But the question of its stability, how the orbits of its members have changed in the past, and what alterations they will undergo in the future is from certain points of view much more important. The solution of the problem of three bodies is a prerequisite for a complete and final discussion of the origin of the solar system, its past evolution, and its prospects for the future—questions which have always been of profoundest interest to thinking men.

It is easy to see in a general way the source of some of the difficulty in the problem of three bodies. In order to make the matter perfectly

* Research Associate of the Carnegie Institution of Washington.

concrete consider the sun, Jupiter, and Saturn, neglecting all the other members of the solar system. As was first proved by the founder of celestial mechanics, Sir Isaac Newton, Jupiter would describe an exact ellipse about the sun as a focus if it were not for Saturn (and the other disturbing bodies); and similarly, Saturn would describe an ellipse about the sun as a focus if it were not for Jupiter. The disturbing attraction of Saturn pulls Jupiter somewhat from its elliptical orbit, and similarly Jupiter pulls Saturn from its orbit. These disturbing forces vary in a complicated fashion because the planets move around the sun at different distances, at different rates and in different planes. The effects of the disturbing forces vary in a still more complicated fashion because they depend not only upon the magnitudes of the forces themselves but also upon the parts of the orbits which the disturbed bodies occupy. In spite of the complexity of this problem it can be solved for such a system as the sun, Jupiter, and Saturn. But the fact that Saturn has been pulled from its undisturbed elliptical orbit makes its disturbing effects upon Jupiter different from what they would otherwise have been. The deviations of Jupiter which have been considered result in corresponding secondary effects upon its own motion. Similarly, there are secondary effects upon the motion of Saturn due to the fact that both it and Jupiter have departed from their elliptical orbits by the primary perturbations. These secondary effects on the orbits of both bodies give rise to tertiary perturbations upon each. The tertiary effects give rise to those of the fourth order, and so on in an unending series. The deviations increase very rapidly in complexity with their order, and the fact that they soon become numerically less important in such problems as present themselves in the solar system is the circumstance that has made them tractable by the methods that have so far been employed.

The questions that at once arise are whether the problem of three bodies is soluble and whether it has been solved. The purpose of this paper is to answer these questions so far as they can be answered at the present time without the use of elaborate mathematical discussions. In a certain sense the answer to both of them is in the affirmative. The answer to the second of these questions is in the affirmative in quite a new sense because of a recent remarkable work by Karl F. Sundman of Helsingfors, Finland. In a certain theoretical sense his results far surpass any heretofore secured. His whole discussion is of the very highest order of excellence; in fact it is so highly regarded by competent European judges that the distinguished and venerable editor of *Acta Mathematica*, Professor Mittag-Leffler, invited him to republish the memoir* in detail in his journal whose pages already were enriched by

* The work was originally published in *Acta Societatis Scientarum Fennicae* vols. 34 and 35. It appeared in *Acta Mathematica*, vol. 36 (1913).

the researches of Poincaré, Darwin, and Weierstrass. This is another example of the excellent mathematical work which so frequently comes from Finland. Every student of differential equations and the profounder parts of celestial mechanics has long been familiar with the name of Lindelöff. It shakes one's belief in the justice of the pride in race when he remembers that the Finns are not even of Aryan stock*, and of European peoples are related only to the Hungarians. In numbers they are only five or six millions; they are poor and live in a relatively desolate and inhospitable country; they were subject long to Sweden and now to Russia. In spite of all these conditions, ordinarily considered to be the exact opposite of those which are necessary to give leisure for pursuing the higher things of life, the work which comes from Helsingfors compares most favorably with that produced by many wealthier and more populous peoples.

The present condition of the problem of three bodies will be best understood by giving something of its history. Before taking up the account of its development it should be stated, in order to prevent all misconceptions, that while it is in a certain sense solved it is by no means finished. In fact, it has only been begun.

A necessary prerequisite to the treatment of the problem of three bodies was the discovery of the laws of motion and the law of gravitation. These laws were based on an enormous amount of observational experience from prehistorical antiquity to the culmination in Kepler's laws of the planetary motions. It was from the observations of the motions of the heavenly bodies that men first perceived that there is order in the Universe. This perception lies at the very basis of science, and without it science would not exist. When it was discovered that apparently the heavenly bodies are moving in an orderly fashion, the next problem was to find the laws of their motions. Among those whose names stand out particularly in connection with the solution of this problem are Hipparchus, Ptolemy, Tycho Brahe, and Kepler. The genius of Newton derived from these laws the law of gravitation.

In order to treat the problem of three bodies it was necessary also to have powerful mathematical processes. The development of mathematics has been parallel with that of astronomy; in fact, the latter in very many cases has forced problems in the former and has often pointed to their solution. But back of particular mathematical theories there lie the logical processes by which they are elaborated. These rules of logic are probably an epitome of the relations among the experiences of the race. At any rate, the logical processes are not contradictory to the Universe about us. In the times of the ancient

* It should be stated that the writer is not positively informed as to the race of Lindelöff, Sundman, and other Finnish scientists.

Greeks all the principal rules of logic were definitely formulated. Certain branches of mathematics were extensively cultivated, but the methods of analysis, which alone are sufficient for making progress in the problem of three bodies, were initiated by Newton and Leibnitz in their invention of the calculus. The calculus is but the introduction to the analysis which has grown up in the last two centuries. Those branches of analysis which are particularly valuable in such problems as that of three bodies are especially what is known as the theory of functions of a complex variable and the theory of analytic differential equations based on the theory of functions. Everyone is familiar with the power of the methods of the calculus as compared with those of the more elementary parts of mathematics. The methods of the theory of functions are similarly more powerful than those of the ordinary calculus. It is only by their use that such results as those of Poincaré and Sundman have been secured. The chief difficulty in this paper is to present these highly technical matters in popular terms.

The treatment of the problem of three bodies was begun by Newton in the Principia. On the basis of his law of gravitation he discussed by synthetic, or geometric, methods the deviations of the moon from elliptic motion which are produced by the disturbing action of the sun. He explained qualitatively all the principal perturbations, and secured quantitative results of considerable approximation. He conceived of the moon as moving in an ellipse whose size, shape, and position continually change. This conception, which grows very naturally out of the ideas connected with the problem of two bodies, has been central in a large part of the perturbation theory. There are grounds for believing that in some respects it has been unfortunate, especially in treating the motion of the moon.

The successors of Newton were Clairaut, d'Alembert, and Euler. They developed analysis corresponding to Newton's geometry. Their methods had the generality which is characteristic of analysis, and they were much superior to those of Newton in getting numerical results. But most of their work was devoted to a discussion of the motion of the moon. The methods which they employed were those of successive approximation. The processes were not proved to converge, and therefore no particular properties of the motion of the moon were rigorously established. They were guided, however, by keen physical and geometrical intuitions, and direct observations of the motions of the moon proved that their theories were capable of representing the perturbations with considerable approximation, if not exactly. But theories of this sort, whatever practical value they may have, are not the ones of primary interest in this paper. The center of interest here is on those things which were absolutely proved, with only a secondary interest

in their numerical application. In the line of exact results secured by these men mention may be made of the ten integrals of the motion of the problem of three (or any number of) bodies. The problem of three bodies is of the eighteenth order; that is, eighteen integrals are sufficient to solve it completely. Or, an equivalent statement is that the complete solution involves eighteen arbitrary constants. Of these eighteen integrals, ten were found by the immediate successors of Newton. Six give the theorem that the center of gravity of the system moves in a straight line with uniform speed; three, that the sums of the products of the masses and the projections on the three reference planes of the rates the respective radii describe areas are constants, and the tenth, that the total energy of the system, both kinetic and potential, is constant. No additional integrals are known for the general case.

The chief immediate successors of Clairaut, d'Alembert, and Euler were Lagrange and Laplace. They perfected the theories of their predecessors and developed corresponding theories for the mutual perturbations of the planets. On the whole their work was marked with greater generality than that which had preceded. One of the most interesting conclusions of a general character, to which both Lagrange and Laplace contributed, was that the major axes of the planetary orbits have no secular terms; that is, they do not on the average increase or decrease This result was proved only for perturbations of the first order, and even then by breaking up the differential equations in a manner which was not logically justified. Hence, while the conclusion undoubtedly represents the facts closely for a very long time, it was not completely established. The process was not proved to converge and there was no discussion as to what the higher order terms might indicate. The subject was carried somewhat further by Poisson who proved that so far as the terms of the second order are concerned the conclusions are in a general way the same. Eginitis has found important differences in the terms of the third order, and Poincaré has proved the process does not converge, so that any conclusions which are drawn from it may be erroneous.

So far in the discussion no rigorous solutions of the problem of three bodies have been mentioned, and no rigorous results except those which follow from the ten integrals have been cited. However, in 1772 Lagrange found certain exact solutions of the problem of three bodies. The memoir of Lagrange on this subject has been greatly admired because of the elegance of its form, and the solutions which he proved to exist are very well known. The solutions are characterized by the fact that the bodies move so that the ratios of their mutual distances are constants. Their orbits are plane curves and conic sections with the center of mass as a focus. They move so that the law of areas is

true with respect to the center of mass as an origin. That is, their motion is qualitatively exactly like that in the problem of two bodies. Whatever the relative masses of the three bodies may be, they can be projected from the vertices of any equilateral triangle in such a way that they will always form an equilateral triangle. If the orbits are circles or ellipses the triangle will always be of finite size; otherwise its dimensions become indefinitely great as the time increases indefinitely. Another solution is that in which the three bodies are always in a straight line, which of course changes its position in space. In this solution the relative distances of the three bodies from one another depend upon their relative masses.

No solutions of the problem of three bodies in which the character of the motion was known for an arbitrary interval of time were discovered for more than one hundred years after the memoir of Lagrange. The next solutions having this property were those given by Dr. G. W. Hill in 1878 in his celebrated researches on the lunar theory. He defined certain periodic orbits related to the orbit of the moon, and computed the coefficients of the expressions for the coördinates with a very high degree of precision. In the strictest sense Hill did not solve the problem because he neglected a small part of the disturbing action of the sun, viz., the part known as the "parallactic terms". But his method was extensible almost without change so as to include these terms, and the details were carried out by Brown in the earliest of his papers on the lunar theory. This work of Hill, together with his epoch making memoir on the motion of the lunar perigee, laid the foundation for an entirely new lunar theory which has been completed by Brown at an enormous cost of labor in a splendid series of papers. It is intended here to emphasize the point that starting from a particular *exact* solution of the problem of three bodies as a first approximation a new method of treating the motion of the moon has been developed. It was the first absolute abandonment of the idea, originally due to Newton, of regarding the orbit of the moon as a varying ellipse. The radical departure from standard lines of procedure shows Hill's originality, and the extraordinary skill with which he developed his ideas proves that his mathematical ability is of the first order. While the exact solution discovered by Hill has been of very great value in one of the most important problems in celestial mechanics, the solutions of Lagrange have found almost no applications and have had very little influence on astronomy. The only exceptions to this statement are that a suggested explanation of the Gegenschein has been based on certain properties of the straight line solutions, and some recently discovered planetoids which make an approximate equilateral triangle with the sun and Jupiter have directed attention again to the triangle solutions.

About 1890 Poincaré turned his attention to the problem of three bodies. He brought to bear upon it a fertility of resource and a knowledge of modern mathematics not approached in any other writer. The results he obtained are of the very highest importance theoretically, and will be equally important practically when they shall be elaborated in a form suitable for numerical applications. In his hands celestial mechanics has been entirely recast.

The point of interest in the present connection is that Poincaré proved the existence of a great variety of exact (periodic) solutions of the problem of three bodies. Their properties were very fully specified, and though the coördinates in all cases are given by infinite series, for suitable values of the masses and other constants upon which they depend they may be computed with any desired degree of precision. Since Poincaré paved the way many other writers have proved the existence and showed how to determine many classes of periodic orbits. The theory is one of many symmetries and beauties and has the finish of the theory of elliptic functions. Besides the pleasure that comes from working in a domain where strict logic prevails and where wonderful harmonies appear on every hand, one has the satisfaction of knowing that, as Poincaré has said, these solutions at the present time constitute the single breach into a region hitherto considered inaccessible. He meant by this that at present there is no hope of being able to describe the motion of three or more mutually attracting bodies for indefinite time except through these exact solutions, or by showing that they are limiting cases. In spite of his great genius, Poincaré had to leave certain of the most important questions along this line altogether unanswered.

We now come to the consideration of an altogether different order of ideas. The culmination of this line of argument is the work of Sundman. It is properly called the "culmination" because it was started in a purely formal way by Euler, received in certain important respects its logical foundation by Cauchy and Weierstrass, was carried an important step in another direction by Levi-Civita and Bisconcini, and has been completed by Sundman.

The differential equations, based on the laws of motion and the law of gravitation, which the motion of the three bodies m_1, m_2, and m_3 satisfy are

$$(1)\qquad \begin{cases} \dfrac{d^2x_1}{dt^2} = -k^2 m_2 \dfrac{(x_1 - x_2)}{r_{12}^3} - k^2 m_3 \dfrac{(x_1 - x_3)}{r_{13}^3}, \\ \dfrac{d^2y_1}{dt^2} = -k^2 m_2 \dfrac{(y_1 - y_2)}{r_{12}^3} - k^2 m_3 \dfrac{(y_1 - y_3)}{r_{13}^3}, \\ \dfrac{d^2z_1}{dt^2} = -k^2 m_2 \dfrac{(z_1 - z_2)}{r_{12}^3} - k^2 m_3 \dfrac{(z_1 - z_3)}{r_{13}^3}, \end{cases}$$

and six similar equations obtained by cyclical permutations of the subscripts. The distances $m_1\ m_2$, $m_2\ m_3$, and $m_3\ m_1$ are represented by r_{12}, r_{23}, and r_{13} respectively. The characteristic property of these differential equations is that their right members are analytic functions of $x_1, x_2, \ldots, z_3$; that is, they can be expanded as converging power series in $x_1 - a_1, x_2 - a_2, x_3 - a_3, y_1 - b_1, \ldots, z_3 - c_3$ provided r_{12}, r_{23}, and r_{13} are all distinct from zero if $x_1 = a_1, x_2 = a_2, \ldots, z_3 = c_3$. If the $a_1, \ldots, c_3$ are the initial values of $x_1, \ldots, z_3$ this condition is satisfied unless two or more of the bodies are in collision at the origin of time. This case will be excluded except when it is explicitly assumed.

Suppose the r_{ij} are all distinct from zero at $t = 0$. Then the solutions of equations (1) can be expanded as power series in t of the form

$$(2) \qquad x_1 = a_1 + \left(\frac{dx_1}{dt}\right)_0 t + \frac{1}{2}\left(\frac{d^2x_1}{dt^2}\right)_0 t^2 + \ldots + \frac{1}{n!}\left(\frac{d^nx_1}{dt^n}\right)_0 t^n + \ldots,$$

and similar equations for $x_2, \ldots, z_3$. The first derivatives are arbitrary. The second derivatives can be replaced by the right members of equations (1). The third derivatives can be obtained from the first derivatives of equations (1) whose right members will depend only on the a_1, b_1, c_1 and the first derivatives of $x_1 \ldots, z_3$. This process can be continued and all the coefficients of the series (2) can be expressed in terms of the a_1, b_1, c_1 and the first derivatives of $x_1 \ldots, z_3$. The work gets rather complicated when it is carried far, but it is actually used in some problems, particularly in the determination of orbits, and has been a known process since the days of Euler.

The critical question is whether equations (2) converge under any circumstances, and if so what they are. It was proved by Cauchy approximately one hundred years after the time of Euler that, under the hypothesis on (1) which have been specified, equations (2) converge for values of t which are not too great. In fact, a limit was defined within which they certainly converge, but it was not the largest limit for which they are valid. The largest limit is as yet unknown. It was later shown by Briot and Bouquet that in the special case of one equation, and still later by Picard and Painlevé in the general case, that the solution (2) is the only one taking the specified unital values which is continuous.

Since the series (2) converge and are unique they constitute a perfectly rigorous and general solution of the problem of three bodies. They show that the coördinates are analytic functions of the time but not much else. The fact is that such an infinite variety of functions are representible as converging power series that to say a function is developable in this way does very little to characterize it. The known properties of the solution (2) do not determine whether or not the

motion is periodic, whether or not there will be collisions or infinite separation of the bodies, or any of the other things, depending upon a considerable interval of time, which one might wish to know. They would not enable one to compute the position of a body except for a very short time, and a theory of the motion of the planets or of the moon built up in this way would be of no value whatever. While the series (2) constitute a general solution of the problem it is an essentially useless one.

The question arises whether the solution (2) can not be modified so as to avoid the limitations to which it is subject. In order to discuss this question it is necessary to make some remarks on what it is that limits the realm of convergence of power series. It was proved about ninety years ago by Abel that the domain of convergence of a power series is a circle. That is, if t is regarded as the complex variable

$$t = \rho + \sqrt{-1}\,\sigma,$$

where ρ and σ are real, the values of t, i. e. of ρ and σ, for which the power series converges all lie in a circle. If the circle is of finite radius the series does not converge for any value of t belonging to a point outside of the circle. On the circle of convergence there is at least one so-called singular point of the function. It may be desired in practice to consider the function only for real values of t, but since the singular point which limits the domain of convergence may be complex, it is clear that in the discussion it is necessary to suppose that t is capable of taking all real and complex values. This is one of the reasons why the theory of complex variables has become so important in physical problems where only real values of the variables are ordinarily used in the applications.

Some examples will make the matter clear. The function $\frac{1}{1-t}$ when expanded as a power series in t converges only if t is less than unity in numerical value. This is known from the properties of the geometric series. But the reason from the present point of view is because the function becomes infinite for $t = 1$. Now consider $\frac{1}{1+t^2}$ which can be expanded as a power series in t^2, for example by the binominal theorem. This function is finite for all real values of t, but the convergence of the series does not hold for all real values of t. The function is infinite for $t = \pm\sqrt{-1}$ because for this value of t the denominator vanishes. Since these points are distant unity from the origin the expansion of this function also converges only in a circle whose radius is unity. If the denominator is a polynominal the radius of convergence of its expansion is the distance from the origin to its nearest zero. But the function $(1 - t)^{\frac{1}{2}}$ can be expanded as a power series in t, and since

it is finite for all values of t it might be supposed that the radius of its circle of convergence is infinite. But this conclusion is incorrect. The function has three cube roots and they are all equal for $t = 1$. Such a point is called a "branch-point" and is one of the singular points which limit the circle of convergence of a function. The circle of convergence of this function has the radius unity also. There are other types of singular points and mixtures of all types.

Now return to the consideration of the problem of three bodies. One of the difficulties is determining the location of the singular points of the solution. At present there is no general method of finding them. If they could be located a series of polynomials could be built up out of the power series by a method due to Mittag-Leffler which would converge for all finite values of t except those lying along certain lines joining the singular points to infinity. If there were no singular points for real values of t, this would constitute a general solution of the problem, valid for all real values of t. It must be admitted, however, that its complexity would be such that it would have no practical value. If it could be proved that for any specified initial conditions there is a strip of finite width along the real axis which contains no singular points, then t could be expressed in terms of another variable τ by a well known formula which would transform the strip into a circle. The solution would be expansible as a power series in τ which would converge for values corresponding to the real values of t. This again would constitute a complete solution of the problem for the specified initial conditions, but it would also be of no practical value. And what is still worse, there is no general method of determining when a strip of finite width having no singular points exists.

In the examples it was seen that there are several kinds of singular points. The question arises what kind of singular points occur in the solution of the problem of three bodies. Painlevé proved that there are singular points in the solution only for a collision of two or more of the bodies in real or complex time. In considering a collision the bodies are supposed to be simply mathematical points. If this statement for complex time does not have a definite physical meaning, nevertheless it is perfectly clear and straightforward mathematically. Levi-Civita proved in a characteristically elegant and profound memoir that in the restricted problem of three bodies (i.e. one infinitesimal and the finite bodies describing circles) the only singularities are branch points where three branches coincide. In this respect the functions are like the last example above, but in other respects they are immensely more complicated. Bisconcini extended Levi-Civita's results to the case where all three bodies are finite, but he was compelled to make one assumption which seemed reasonable. Sundman proved that the

assumption is true. Strictly speaking the results of Levi-Civita hold in general without important modification only when not all three constants of the integrals of areas are zero. When they are zero Sundman has proved that the three bodies simultaneously collide, and as they approach collision they approach the equilateral triangle configuration of Lagrange.

Now consider the case where not all three of the constants of the integrals of areas are zero. This is of course the general case and is the one treated by Sundman in his memoir in *Acta Mathematica*. He defines a variable u, following Levi-Civita, in terms of which the coördinates and t can be expressed as power series, whether or not the bodies are in collision. He then defines a new independent variable w having the desirable properties of u and certain very important additional ones. When expressed in terms of it the solution for arbitrary initial conditions, with the exception of the single restriction that not all three of the constants of the areas integrals shall be zero, has no singularities in a strip of finite width along the real axis which corresponds in a one-to-one, finite-to-finite, way with the variable t. When the strip is transformed to a circle by introducing the new independent variable τ, as described above, the solutions converge for values of τ corresponding to all the real values of t. Moreover, the coefficients of these series can be determined from the original differential equations. Hence the problem is theoretically solved. The conjecture which has sometimes appeared in popular books, that the problem of three bodies could be solved only when new functions were discovered, has thus been shown to be incorrect—power series are entirely adequate.

The work of Sundman is of the highest excellence from the mathematical point of view, but astronomers will wish to know about its practical value. On this point the report must be unfavorable. Practically it has all the defects of (2) except the limitation on the range of validity. It gives no properties of the motion, no answer to the questions the astronomer raises, and there is no hope of its being practically applied. The problem of three bodies, in many respects which have not been elaborated here, still challenges mathematicians, and there is little prospect of its being soon finished.

The University of Chicago.

Jan. 14, 1914.

WINSLOW UPTON.

FREDERICK SLOCUM.

Winslow Upton, professor of astronomy and director of the Ladd Observatory, died of pneumonia at Providence, R. I., on January 8, in the sixty-first year of his age.

Professor Upton was born in Salem, Mass., October 12, 1853. His parents were James and Sarah Sophie (Ropes) Upton. He attended the public schools of Salem, and, in the high school, had as class-mates two other boys who also became eminent astronomers, Professor Frank W. Very, of Westwood, Mass., and Professor Albert S. Flint, of Madison, Wis.

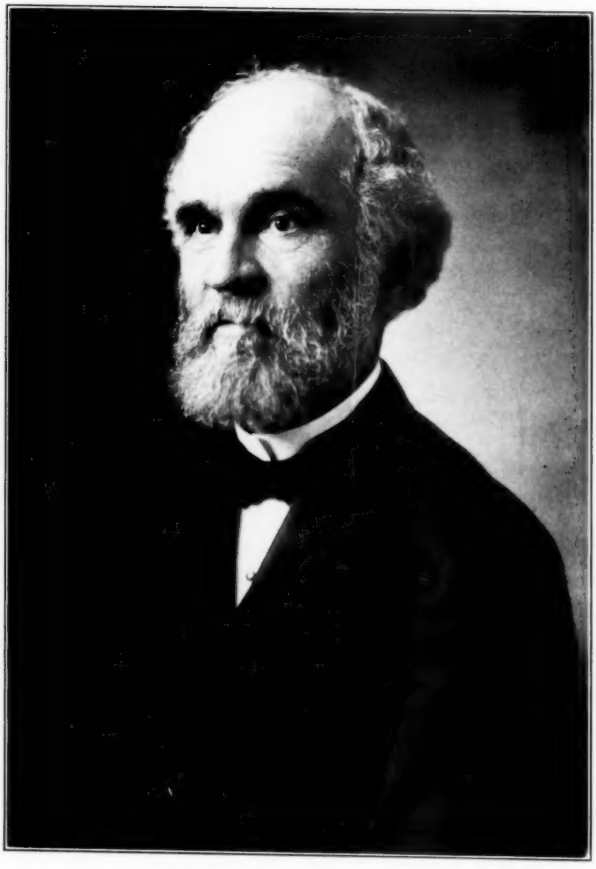
After graduating from the high school he devoted some time to the study of music, and then entered Brown University in 1871. He graduated as valedictorian of his class in 1875, receiving the degree of A. B. In 1906 his Alma Mater bestowed upon him the honorary degree of Sc.D.

From 1875 to 1877 he was an assistant and student in the Mitchell Observatory of the University of Cincinnati, from which University he received the degree of A. M. in 1877. During the next two years he was an assistant in the Harvard College Observatory. In 1879-80 he was assistant engineer in the U. S. Lake Survey, in 1880-81 computer in the U. S. Naval Observatory, and from 1881 to 1883, computer and assistant professor of meteorology in the U. S. Signal Service. In 1883 he was appointed professor of astronomy in Brown University, which position he held at the time of his death.

When Professor Upton went to Brown he found a very meagre equipment for his astronomical work, but, a few years later, through the generosity of the late Herbert W. Ladd, then the governor of Rhode Island, an excellent observatory was erected at a cost of approximately $30,000. The planning of the observatory and its equipment was entirely in the hands of Professor Upton. At the time of its dedication, in 1891, the Ladd Observatory was considered one of the finest observatories for teaching purposes in the country.

In the early days of his connection with Brown, Professor Upton taught classes in mathematics, meteorology, and logic as well as astronomy. He was secretary of the faculty 1884-91, Dean of the University 1900-01, and for many years a member of the most important university

PLATE XIII



WINSLOW UPTON

1853–1914

committees. He was a fellow of the American Association for the Advancement of Science, a member of the Deutsche Meteorologische Gesellschaft, of the Phi Beta Kappa and Sigma Xi Societies, and of the Delta Upsilon Fraternity.

Although Professor Upton always carried a heavy burden of teaching and administrative duties, he never lost his zeal for astronomical research. He went on no less than six expeditions to observe total eclipses of the sun in various parts of the world; in 1878 near Denver, Colo., in 1883 on the Caroline Islands in the South Pacific, in 1887 in Russia, in 1889 at Willows, Cal., in 1900 at Fentress, Va., and in 1905 near Winnipeg, Canada.

During his sabbatical year 1896-97, he was research assistant at the Harvard College branch observatory at Arequipa, Peru, and again, during his sabbatical year 1904-05, he was for a time connected with the Solar Observatory of the Carnegie Institution, on Mount Wilson, near Pasadena, Cal.

At the Ladd Observatory, in connection with his assistant Mr. John Edwards, he maintained a continuous time service for the city of Providence and vicinity, conducted routine meteorologial observations for the U. S. government, made regular observations of sun-spots, kept a continuous photographic record of the degree of cloudiness of the night sky, and, as opportunity offered, made occasional observations of comets, asteroids, meteors, etc.

Professor Upton's publications include the following:

1. "The Solar Eclipse of 1878," a lecture before the Essex Institute (*Bulletin of the Essex Institute*, Vol. 11. 1879; reprinted, pp. 19).
2. "Photometric Observations Made Principally with the Equatorial Telescope of Fifteen Inches Aperture During the Years 1877-79;" by E. C. Pickering, C. Searle and W. Upton (*Harvard Astr. Obs. Ann.*, Vol. 11, 1879, pp. 317).
3. "Information Relative to the Construction and Maintenance of Time-Balls" (Washington, 1881, pp. 31 + 3 pls., U. S. War Dept. Professional papers of the Signal office, No. 5).
4. "Lectures on Practical Astronomy," 1882 (Report of the Chief Signal Officer, Washington, 1882, pp. 104-120).
5. "On the Methods adopted in the Computation of Barometric Reduction Constants" (Report of the Chief Signal Officer, Washington, 1882, appendix 61, pp. 826-846. Washington, 1883).
6. "The Use of the Spectroscope in Meteorological Observations" (U. S. signal service notes, No. IV., pp. 7 + 3 pls., Washington, 1883).
7. "Report of Observations made on the Expedition to Caroline Islands to Observe the Total Eclipse of May 6, 1883" (reprinted from *Memoirs of the National Academy of Sciences*. Vol. 2, Washington, 1884, pp. 64 + 7 pls).
8. "Distribution of Rainfall in New England February 10-14, 1886, from Observations reported to the New England Meteorological Society" (reprinted from *Science* of March 19, 1886, *Providence*, 1886, pp. 8).
6. "An investigation of Cyclonic Phenomena in New England" (1887).

10. "Meteorological Observations During the Solar Eclipse August 19, 1887, at Chlamostina, Russia" (reprinted from the *American Meteorological Journal*, Ann Arbor, 1888, pp. 25).

11. "The Storm of March 11-14, 1888" (reprinted from *American Meteorological Journal*, May, 1888, pp. 19).

12. "Characteristics of New England Climate" (*Harvard Astr. Obs. Ann.*, Vol. 21, 1890, pp. 265-273).

13. "Meteorological and Other Observations made in Connection with the Total Solar Eclipse of January 1, 1889, at Willows, California," by W. Upton and A. L. Rotch (*Harvard Astr. Obs. Ann.*, Vol. 29, 1892, pp. 34 + 2 pls.).

14. "Star Atlas, Containing Stars Visible to the Naked Eye and Clusters, Nebulæ, and Double Stars Visible in Small Telescopes . . . and an Explanatory Text" (Boston, Ginn and Co., 1896, pp. iv + 34.)

15. "Geographical Position of Arequipa Station" (*Harvard Astr. Obs. Ann.*, Vol. 48, 1903, pp. 52 + 1 pl.).

He was also the contributor of numerous short articles to the *Astronomische Nachrichten* since 1877, to *Zeitschrift für Meteorologie*, *Sidereal Messenger*, POPULAR ASTRONOMY, *Science*, *American Meteorological Journal*, *Astronomical Journal* and other scientific publications. For over twenty years he wrote monthly letters on astronomical topics for the *Providence Journal* and was editor of the astronomical part of the Providence Journal Almanac 1894-1910.

In 1882 Professor Upton married Miss Cornelia Augusta Babcock, of Lebanon Springs, N. Y., and he is survived by his wife and their two daughters, Eleanor Stuart and Margaret Frances, both of whom are graduates of Smith College.

For many years Professor Upton was prominent in the affairs of the Episcopal church in both his city and state. At the time of his death he was senior warden of the church of the Redeemer in Providence, of which church he had been a member of the vestry for over twenty-five years. He was on the standing committee of the diocese and of the cathedral corporation, and was treasurer of the board of managers of diocesan missions.

From his father Professor Upton inherited a strong love for music. While in college he was director of a glee club and church organist. Throughout his life he maintained his interest in music, and during the later years, was director of music in the Church of the Redeemer, which position is now held by his younger daughter.

As an investigator Professor Upton possessed the true scientific spirit, and, in his teaching, he laid great emphasis upon the principles of the "scientific method" which he expounded so clearly in his early courses in logic. To a rare degree he possessed the power of keen perception, clear interpretation and lucid exposition. His enthusiasm for his beloved science was contagious. and his influence as a man of the highest ideals, of sound common sense, of genial and kindly spirit will long be felt by all who were in any way associated with him.

The following resolutions have been adopted by the Faculty of Brown University and by the Society of Sigma Xi respectively.

We, the Faculty of Brown University, take this means of expressing our sense of loss by reason of the death of our dear friend and distinguished colleague, Professor Winslow Upton, A.M. Sc.D.

Of his career, the principal part has been in connection with this University; a pupil in the class of 1875, he was recognized as a brilliant scholar. Later he was Professor of astronomy, Director of the Ladd Observatory, and sometime Dean of the University; in these positions and in his less conspicuous, but not less arduous and useful labors as member of many committees, he was a most valued officer of the institution.

We do not forget nor undervalue his services to the Federal government, and to Harvard University, in lines connected with his chosen field of life work; nor do we overlook the fact that he found opportunity to journey to Russia, to South America, and to other remote regions, to study their starry heavens.

A learned teacher, he acquired the respect, the confidence and the affection of his pupils.

An active member of the Christian church, skilled in music, strong in counsel, fervent in piety, he served most faithfully the communion to which he was attached.

A loyal friend and an honest man, his heart was open to every valid appeal.

Remembering now the loveliness of his character, and the high excellence of his work, we adopt this brief tribute as a part of our permanent records and as a memorial to be communicated to his afflicted family.

The committee appointed to prepare a minute for the record of the society on the recent death of Professor Upton beg to submit the following:—

With deep and genuine sorrow we record the death of our colleague and charter member of the Brown Chapter of Sigma Xi, Professor Winslow Upton.

Professor Upton was a graduate of Brown. He had served the University with notable ability and devotion as professor of astronomy for thirty years and as director of the observatory since its establishment twenty years ago. His scientific achievements which easily entitle him to an honorable place in the roll of members of the society of Sigma Xi were appropriately recognized by his Alma Mater in the honorary degree of Doctor of Science.

His teaching was exercised by clarity of exposition, enthusiasm and the personal touch that adjusted the scientific truth into the scheme of human experience. His personality which commanded universal respect for its obvious integrity and for soundness of judgment was nevertheless singularly buoyant, genial and altogether winsome,

In his death our chapter of Sigma Xi loses one of its most worthy members in the midst of his scientific attainment and influence; we the members of the society are bereft of a colleague and friend whose memory will always abide deep in our hearts.

THE MOONS OF MARS.

CHARLES NEVERS HOLMES.

As our own beautiful satellite shines whitely and brightly upon us—upon indistinct and shadowy hills and vales mantled with the verdancy of summer or shrouded with the ice and snow of winter—we of this small terrestrial planet may perhaps ponder upon some other satellite or satellites, upon those of Saturn or Jupiter, and then remember that ruddy Mars is also attended by two moons.

Two moons! Minute, invisible to man's unassisted eyesight! How Sir William Herschel watched and watched, in 1783, to discern the faint glimmer. How he must have studied with his crude glass the darkened environments of the red reflecting planet. How many others after him must have sought long and carefully for these tiny satellites of Mars, only at last to abandon the search, and concur with the general opinion that this ruddy planet like Venus was moonless. Sir William Herschel and these others passed away, and other astronomers with their telescopes studied the starry skies; but the two tiny satellites of Mars still revolved around and around their primary planet, without terrestrial detection. In 1862, however, there was an earnest, systematic attempt to discover any possible martian moon, and D'Arrest at Copenhagen labored faithfully but futilely. More than one decade passed after this attempt of D'Arrest, and still these satellites remained invisible to the eye of man. Then, suddenly, in the year of 1877, it was publicly announced that Mars possessed not one moon but two moons, both, of course, exceedingly minute and inconspicuous.

Professor Asaph Hall was born in Connecticut (1829), and became an assistant to Professor Bond of the Harvard Observatory in 1857. Later, he was appointed an assistant in the Naval Observatory at Washington, and, still later (1895), he was again associated with Harvard University as professor of astronomy. Not only did Professor Hall accompany several important astronomical excursions but he contributed also valuable information respecting double stars, as well as performing a vast deal of routine astronomical work. In 1877, it happened that Mars approached unusually near to our Earth, and Professor Hall decided that August would be an excellent time to search for a possible satellite with the 26-inch refracting telescope at the Washington

observatory. Accordingly, he began a careful examination of the region immediately around Mars, but at first his telescope revealed nothing extraordinary, only some small stars. However, he continued his search, and on the 11th of August discovered a dim star which was later proven to be the *outer* satellite of the ruddy planet. Professor Hall was prevented by bad weather from further investigation until August 16, when he again discerned a dim star which under observation indicated that it was a satellite in motion with Mars. On the following night, while watching for the satellite first seen, Professor Hall discovered a second satellite which afterwards was proven to be the *inner* satellite of Mars. On the following nights careful observations made it positively certain that two martian moons had been found, and their discovery was, accordingly, announced to an interested world. The motions of the second or inner satellite, however, puzzled and perplexed Professor Hall, for this tiny moon had the habit of appearing upon different sides of Mars on the very same night, and, accordingly, at first he believed that the planet possessed two or three satellites inside of the orbit of the outer satellite. However, on August 20, and 21, he made a very careful observation of the inner satellite, and satisfied himself that there was only one inner moon, its peculiarity of frequent reappearance being due to its rapid revolution around Mars.

Of course, the announcement by Professor Hall was received with enthusiastic interest by the astronomical world; and, between the time of that announcement and the last of October, watchers at the greater observatories in Europe and America closely studied the newly found satellites. In 1879, and again in 1881, there occurred favorable opportunities to observe the moons of Mars, which in the meantime had been given the respective names of Deimos and Phobos. These names were suggested by Mr. Madan of Eton, Deimos and Phobos being the mythological horses that drew the chariot of the war-god Mars. The outer satellite—discovered on the night of August 11, 1877—was called Deimos, while the inner satellite—discovered on August 17, the satellite that had at first so puzzled and perplexed Professor Hall—was named Phobos. As has been stated, both these martian satellites are very small, wholly invisible to the unassisted eye of man.

The outer moon, Deimos, is at the distance of 14650 miles from Mars, a distance that may be compared with that of our own moon from the earth, a mean of about 238,000 miles. It is at a much lesser distance than any of the other solar-system satellites from their primaries, with the exception of its companion Phobos. Its periodic time of revolution around Mars occupies one day, 6 hours, 17 minutes and 54 seconds, that of our own moon around the earth occupying 27 days, 7 hours, 43 minutes and 11 seconds. In comparison with these astronomical

statistics, the inner moon, Phobos, is at the distance of 5850 miles from Mars, about 8800 miles nearer than Deimos. Phobos is, therefore, the closest of satellites to their primaries. the eighth satellite of Jupiter being estimated to be as far away as 15,600,000 miles. The periodic revolution of Phobos around Mars occupies only 7 hours, 39 minutes and 15 seconds, that of Mars around the Sun taking about 787 days. It is thus to be seen that Phobos is a very unique and remarkable satellite, and one of its astronomical peculiarities is that it has a habit of rising in the *west* and setting in the *east.*

This peculiarity of the satellite Phobos is easily explained by the fact that it is the only moon in our solar system that revolves around its planet faster than that planet rotates upon its axis. In other words, while Mars is turning around once, its inner moon is revolving three times around it. The rotation of the ruddy planet takes about 24 hours, the revolution of Phobos around the planet takes about 7 hours, therefore the satellite would set rapidly in the east, to any possible inhabitants upon the martian surface, and rise rapidly in the west. That is. it keeps overtaking these possible citizens of Mars, riding upon the planetary surface, instead of these citizens overtaking it. Were these possible inhabitants to overtake it—as in the case of the more distant satellite Deimos—this peculiar moon would rise naturally in the east. As it is, however, Phobos rises in the west; but the inhabitants of Mars—if it possesses any—must be pretty well accustomed to the sight by this time,and, moreover, the Martians do have a moon—Deimos—that rises in the east.

The orbits of both these satellites appear to have a regular form, and both moons move close to the equatorial plane of Mars. Both Deimos and Phobos are often eclipsed, the latter twice out of every three full moons; and Phobos, as viewed from the martian surface, would frequently be seen to transit across the Sun's dazzling disk. Of course, owing to the smallness of these satellites, their "moonlight" is not strong, despite their proximity, that of Phobos equalling only about 1/60th the light of our moon while Deimos gives but 1/1200th of the light of Queen Luna. Respecting firmamental magnitudes, the brightness of Phobos at opposition is about that of a star of the fourteenth magnitude, while Deimos possesses about the thirteenth magnitude. Such faint magnitudes are wholly telescopic, and since these satellites at their nearest are, comparatively speaking, not so very far distant, it follows that they must be small in size. Such is the case, Professor Pickering estimating the diameter of Phobos at about 7 miles, that of Deimos at about 5 or 6 miles. Other astronomers have variously calculated the respective diameters of these martian moons, but their

smallness, as well as the distance, makes absolute certainty difficult. It seems probable, however, that the diameter of neither Deimos nor Phobos exceeds 20 miles.

So small and insignificant are these satellites of Mars that even the telescopes and telescopic photographs of this twentieth century do not tell us of the earth very much concerning them. What the future will reveal respecting these moon-mites is entirely problematical, but the outlook may be more promising than many of us suppose at present.

Dover, N. H., 147 Locust St.

VARIABLE STAR OBSERVING.

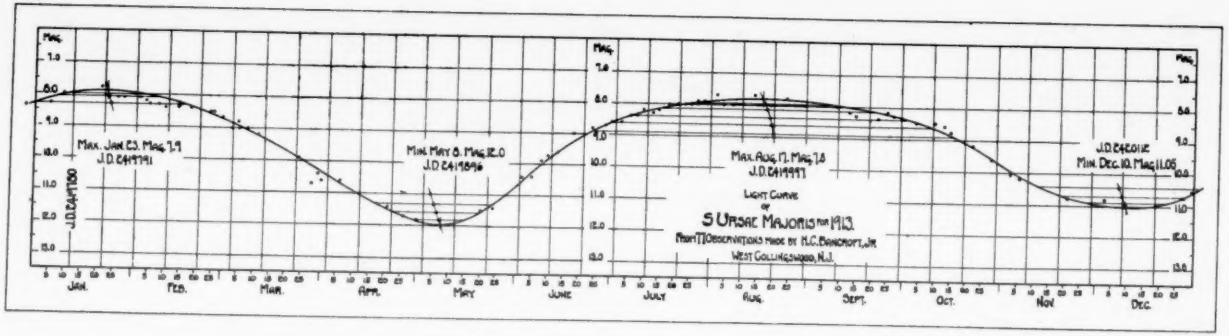
H. C. BANCROFT, Jr.

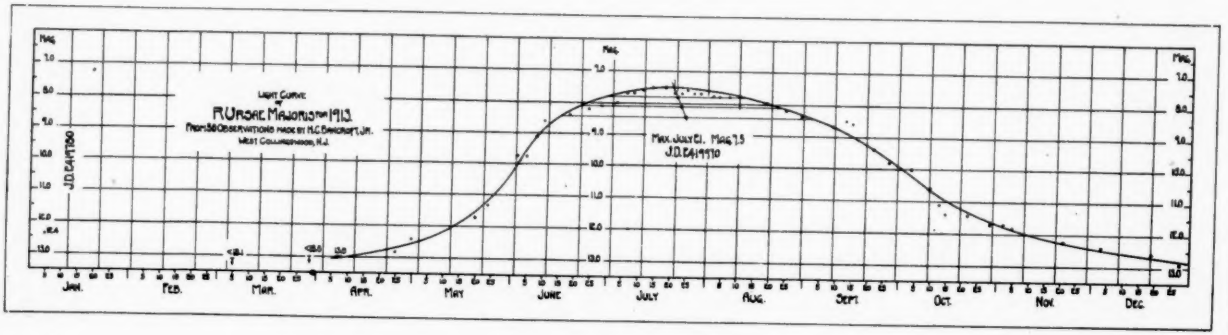
In these days of great telescopes and elaborately equipped observatories, the question is often asked, "what can a man with a modest telescopic equipment accomplish in the way of research work, even if he desires to add his mite to the sum of astrophysical knowledge?" Is there any line of work left open for him which counts for anything and has a definite and positive value?

At first thought it would appear that he could do little, if anything, that was of actual service, but when we turn to the subject of variable stars we find there a fertile field of research work open to all who care to delve in it. Here the observer with a small glass, say even a three-inch refractor, can accomplish a great deal that is of value scientifically by observing closely the fluctuations in the light of these wonderful and mysterious suns. They present a baffling enigma that can only be definitely solved by the acquisition of an enormous amount of data which the small telescope can supply quite as well as a large glass.

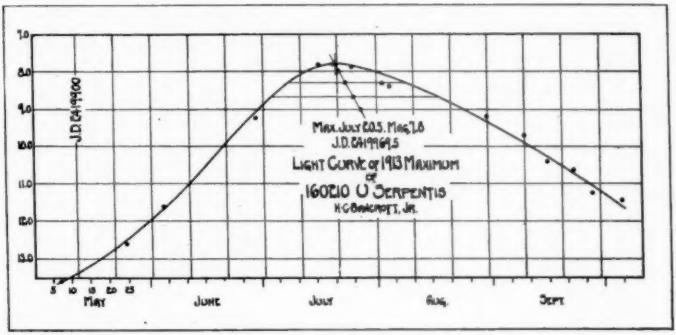
Thanks to the generosity of Professor E. C. Pickering, director of the Harvard College Observatory, charts of the variable star fields are supplied to observers gratis. The method of observation is simple. It involves no mathematics and is easily mastered in a short time. Constant practice soon yields surprising results, and the observer has the satisfaction of knowing that he is engaged in a work that is of value and that the time he spends in observing is well spent.

Observers of variable stars in this country have formed an organization. It is known as "The American Association of Variable Star Observers" and is under the direct supervision of Professor E. C. Pickering, director of Harvard College Observatory. It has a membership of thirty observers, and has just completed its second year of work.


Max. Jan 23. Mag 7.9
J.D. 2419741
Min. May 6. Mag 12.0
J.D. 2419896
Max. Aug 17. Mag 7.8
J.D. 2419997
J.D. 2420112
Min. Dec. 10. Mag 11.05
Light Curve
of
S Ursae Majoris for 1913.
From 77 Observations made by H.C. Bancroft, Jr.
West Collingswood, N.J.
J.D. 2419700
Mag.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.


Light Curve
of
R Ursae Majoris for 1913.
From 58 Observations made by H.C. Bancroft, Jr.
West Collingswood, N.J.
Max. July 21. Mag 7.5
J.D. 2419770
J.D. 2419700
Mag.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

In that time it has contributed to the Harvard College Observatory over 19,000 observations. These are all published in the *Harvard Annals*, and thus the results are on record for all time.



From the observations made by the writer during 1913 he has been enabled to draw curves of the circumpolar variables R, S and T Ursae Majoris for the entire year, besides the maxima and minima of some half dozen others*. R, S and T Ursae Majoris are shown here.†

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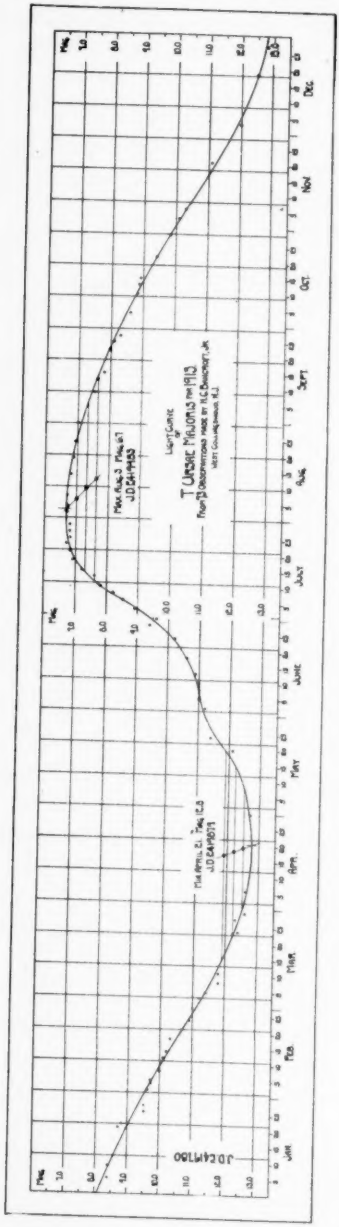
* Mr. H. C. Bancroft, Jr., of West Collingswood, N. J., whose skilful work is evidenced by the beautiful light curves shown herewith, has made a record in observing variable stars that any observer may well be proud of. Mr. Bancroft has a 5½-inch refractor, and joined the Association in November 1912. In the short time that has elapsed since then he has made over 1900 observations. He holds the Association record for a single month's work, 400 observations, and observes eighty or ninety long period variable stars each month. His work has enabled him to derive from his own observations these splendid light curves.

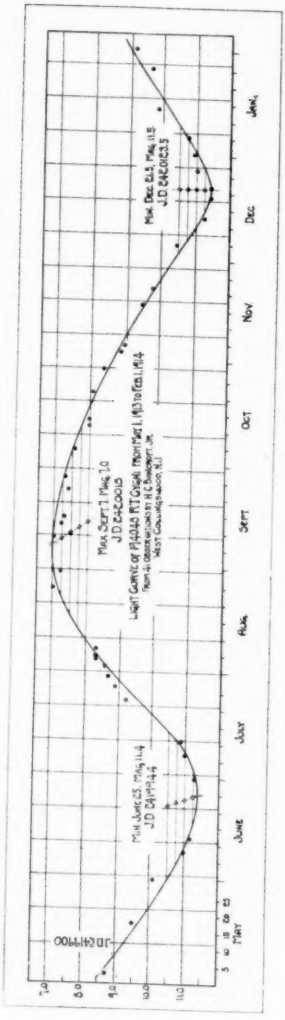
The work done by Mr. Bancroft and many other able observers of the Association offers the best of proof that there is a field of observational work open to those who are willing to coöperate in it, that is well worth while. Several observers in the Association observe with three-inch refractors mounted on tripod, and even such a modest equipment answers the purpose admirably.

There is a fascination about the work difficult to describe, that soon engenders keen interest and enthusiasm. New fields constantly lure the observer on, and irregular variables require close observing as they are subject to startling and unexpected variations. The work has much to commend it. It is never monotonous, offers great variety, and best of all is most practical. This can be said of few lines of observational work open to the observer with a small glass.

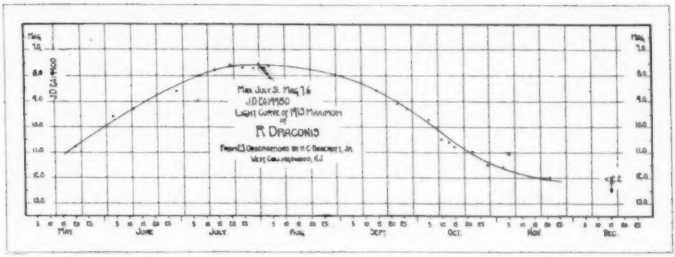
Monthly reports of the work appear in "Popular Astronomy". The secretary will be glad to hear from any observers who desire further information or who care to join the Association. W. T. O.

† Later Mr. Bancroft sent us the curves for RT Cygni, U Serpentis, R Draconis and RV Herculis, which are included here with the others. Editors.


Light Curve
T URSAE MINORIS for 1913
From 73 observations made by H.C. Bowdoin, Jr.
Mean Rise 3 Mag 6.1
J.D. 2419453
Mid-April Cl. Mag 12.5
J.D. 2419801
J.D. 2419180
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec


Max. Sept 1 Mag 7.0
J.D. 2420015
Light Curve of R HYDRAE RT CRATERIS from Harvard Photometric Data
from observations by H.C. Bowdoin, Jr.
West Cambridge, Mass.
Mid-June Cl. Mag 11.4
J.D. 2419744
Max. Dec 8.5 Mag 11.5
J.D. 2420163.5
J.D. 2419180
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan.

These curves seem to illustrate three types of variables:—R Ursae, a fairly short maximum and long minimum, S, a long maximum and short minimum, and T about the same length maximum and minimum. The sharp and smooth rise of R should be noticed and the gradual

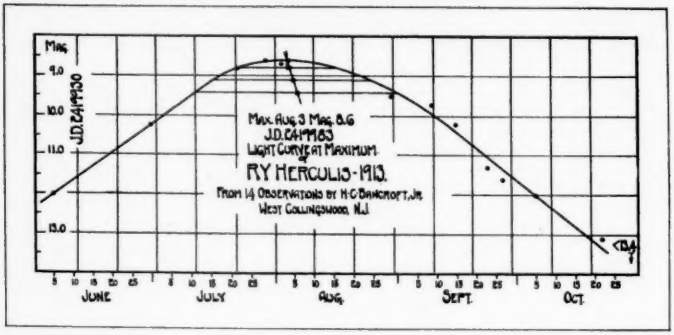


decline, while T, having as sharp or sharper rise has also a well defined "hump" or pause in the curve at about the first of June. This is too

COÖRDINATES OF THE CURVES.

Magnitude for each 20th J.D.				Magnitudes and Corresponding J.D.					
J.D.	Magnitudes			R Ursae		S Ursae		T Ursae	
	R	S	T	Mag.	J.D	Mag.	J.D.	Mag.	J.D.
2417980	12.5	7.95	8.6	12.5	2419780	8.0	2419778	8.5	2419778
9800	—	7.95	9.55	13.0	9866	8.0	9802	9.0	9789
9820	—	8.45	10.7	12.5	9890	8.5	9821	9.5	9800
9840	—	9.3	11.8	12.0	9901	9.0	9833	10.0	9808
9860	13.05	10.45	12.55	11.5	9908	9.5	9844	10.5	9817
9880	12.75	11.55	12.75	11.0	9913	10.0	9852	11.0	9825
9900	12.05	11.9	12.35	10.5	9917	10.5	9861	11.5	9835
9920	10.1	10.6	11.15	10.0	9921	11.0	9869	12.0	9844
9940	8.1	9.05	10.4	9.5	9924	11.5	9880	12.5	9858
9960	7.55	8.2	7.65	9.0	9928	12.0	9896	12.5	9895
9980	7.6	7.9	6.7	8.5	9933	11.5	9908	12.0	9907
2420000	8.0	7.8	6.85	8.0	9942	11.0	9915	11.5	9913
0020	8.7	7.95	7.4	7.5	9969	10.5	9921	11.0	9926
0040	9.85	8.3	8.2	8.0	2420000	10.0	9929	10.5	9937
0060	11.2	9.1	9.25	8.5	0015	9.5	9933	10.0	9944
0080	11.95	10.25	10.45	9.0	0026	9.0	9941	9.5	9948
0100	12.4	10.9	11.65	9.5	0034	8.5	9952	9.0	9952
0120	12.7	10.95	12.5	10.0	0041	8.0	9971	8.5	9955
				10.5	0048	8.0	2420022	8.0	9957
				11.0	0056	8.5	0046	7.5	9961
				11.5	0066	9.0	0058	7.0	9967
				12.0	0081	9.5	0067	7.0	2420006
				12.5	0107	10.0	0075	7.5	0022
						10.5	0085	8.0	0035
						11.0	0106	8.5	0045
						11.0	0118	9.0	0055
						10.5	0133	9.5	0064
								10.0	0073
								10.5	0081
								11.0	0089
								11.5	0097
								12.0	0107
								12.5	0120

pronounced to be ignored. The decline of T is very much more gradual than the rise and is somewhat similar to that of R.



The gradual rise and decline of S is shown by the curve, the rise starting almost immediately after the minimum has been reached. The

COÖRDINATES OF THE CURVES.

Magnitude for each 20th J.D.					Magnitudes and Corresponding J.D.							
	Magnitudes				RT Cygni		U Serpentis		R Draconis		RY Herculis	
J.D.	RT Cygni	U Serpentis	R Draconis	RY Herculis	Mag.	J.D.	Mag.	J.D.	Mag.	J.D.	Mag.	J.D.
2419890	8.5	—	—	—	8.5	2419890	13.0	2419906	10.5	2419911	12.0	2419924
9900	9.25	13.4	11.3	—	9.0	9896	12.5	9913	10.0	9919	11.5	9931
9920	10.6	12.7	9.95	12.3	9.5	9903	12.0	9919	9.5	9927	11.0	9938
9940	11.35	9.9	8.75	10.85	10.0	9910	11.5	9925	9.0	9935.5	10.5	9944.5
9960	10.75	8.1	7.9	9.4	10.5	9919	11.0	9930	8.5	9946	10.0	9952
9980	8.75	8.0	7.6	8.6	11.0	9928	10.5	9934.5	8.0	9956.5	9.5	9958.5
2420000	7.35	8.8	7.75	8.9	11.0	9956.5	10.0	9939	8.0	2420011	9.0	9966.5
0020	7.0	9.9	8.3	9.95	10.5	9962.5	9.5	9943.5	8.5	0024	9.0	2420002
0040	7.35	11.2	9.4	11.5	10.0	9968	9.0	9948.5	9.0	0033.5	9.5	0012.5
0060	8.05	—	10.85	13.1	9.5	9972	8.5	9954	9.5	0042	10.0	0020.5
0080	9.00	—	11.8		9.0	9977.5	8.0	9962	10.0	0048	10.5	0027.5
0100	10.2				8.5	9983	8.0	9979.5	10.5	0055.5	11.0	0033
0120	11.4				8.0	9989	8.5	9992.5	11.0	0062	11.5	0040
0140	10.65				7.5	9997	9.0	2420003.5	11.5	0072	12.0	0046
0160	9.25				7.0	2420018	9.5	0013	12.0	0088.5	12.5	0052
					7.5	0045	10.0	0021.5			13.0	0058.5
					8.0	0058.5	10.5	0030				
					8.5	0068.5	11.0	0037				
					9.0	0080	11.5	0045				
					9.5	0088						
					10.0	0096.5						
					10.5	0104.5						
					11.0	0112						
					11.5	0123.5						
					11.0	0134						
					10.5	0142						
					10.0	0149.5						
					9.5	0156.5						
					9.0	0163						

maximum of August 17 is much broader than that of January 23, but is of the same magnitude. The minimum of December 10 is fully a magnitude brighter than that of May 8, but is much broader. The last decline required 10 days longer than the first.

The unit of the ordinates is one magnitude and of the abscissas ten Julian Days. The days and months of the calendar year are given at the bottom of the charts.

In the tables the magnitudes for each twentieth J.D., and the J.D. for each half magnitude are given.

West Collingswood, N. J.
January 20 and February 23, 1914.

OBSERVING MARS.

GILBERT LANHAM.

Ruddy Mars is now past opposition, although much too distant for favorable observation. Yet, considering its presentd istance, Mars continues to exhibit those surface features which are so differently seen by those possessing telescopes of sufficient power. I had the opportunity to examine this planet through the 16-inch refractor at the Lowe observatory, Echo Mt., Cal., where I spent five days commencing on December 15, last.

Each night, except one, while observing Mars, I was not satisfied with the state of the atmosphere; although clear, it was disturbed. During any of the five nights the major or natural features on the planet were conspicuously evident. They were as plain as the continents on the terrestrial globe. The Fastigium Aryn and Sabaeus Sinus both appeared about midnight, while the Syrtis Major disappeared about 5:00 A. M. The Hammonis Cornu, Mare Icarium, the Wedge, Deucalionis Regio, Mare Erythraeum (this was not uniform in shade), Hellas, Margaritifer Sinus, Pyrrhae Regio and others were some of the very plain markings. The Nix around the north pole of Mars, with the polar sea bordering on the south, showed itself prominently. The northern hemisphere appeared to be in mid-winter stage, or better, emerging from winter.

Now as to the canals. Not one typical Martian canal was perceptible. A western portion of the Nilosyrtis, a very wide canal, was the only one discernible, while not one in the remainder of the multitude of typical canals of the hemisphere in view was apparent. At 2:30 A. M., December 20, the air was at its best,—in fact, the finest I have ever

seen at the Lowe Observatory, and Mars was somewhat past the meridian. The disk was apparently very little disturbed by restless air waves, as seen with a power of 385 on the 16-inch refractor. After spending some thirty minutes anxiously watching at those moments of best "seeing", with powers of 115, 195, 385 and 460 diameters, and catching not the slightest glimpse of a canal, the Nilosyrtis excepted, I ceased looking for the objects. With a power of 460, about 29 to an inch of aperture, the lines of demarcation between the yellow-pink and muddy-green regions were by no means indistinct as they are so frequently depicted, but nearly as sharp cut as the disk itself, thus showing no over magnification. As the powers were raised from 800 to 1000 diameters, these two only for experiment, the color of the disk was greatly lightened, while all the visible surface features apparently squirmed about to some extent. Now magnification and the condition of the atmosphere were out of harmony. Stopping down the aperture of the 16-inch to 12 inches and then to 8 inches did not seem to help me in my hope to see a typical canal. Here is an instance, then,where an observer knows a certain thing ought to be visible and yet he can actually see no trace of it. According to the illusion theory of the canals of Mars, weighty contributions on which can be found in magazines of the past, an abundance of immaterial linear objects extending between projections of the dark areas, and across the so-called deserts, should be conspicuous to any observer who does not even suspect the existence of fine lines on the Martian disk. Whether or not any canals on the hemisphere observed by myself were visible to any other observer during the dates mentioned above, I have not inquired.

To show that the observer's eyes are not defective, it might be proper to relate that, on a previous night, I could easily resolve with the instrument the trapezium of Orion, seeing six of its brighter stars with a power of 83. With a power of 18 on the 3-inch finder the four brighter stars of the same system were visible, and with the same instrument and power, the annular character of the well known ring-nebula in Lyra was fairly exhibited to me several months before. I have also seen Epsilon Lyrae resolved by a power of 43 on a 4-inch Brashear refractor.

As was previously stated, a high power on the Lowe telescope apparently caused the visible features and, therefore, the lines of demarcation on Mars, to become indistinct, on account of the light therefrom passing through our perturbed atmosphere. This also applies to other instruments. What I saw of Syrtis Major with a power of 800, or 1000, is finely illustrated in POPULAR ASTRONOMY, Vol. XXI, p. 419, Figs. 9 and 10, With a power of 385, the lines of demarcation appeared nearly as sharp as those represented in Figure 8 on the same page. A power proportionally higher on a very large instrument is capable of causing such

fine objects as the canals and lines of demarcation to appear much worse when viewed through an unsteady atmosphere. If the rather sharp lines of demarcation appear clear cut under 385 or 460 diameters on a 16-inch, in the same atmospheric conditions could a power of 1000 on a refractor of twice the diameter be expected to resolve much finer lines so as to make them appear a long mass broken up in structure, as shown in the same volume on p. 418, Figs. 5 and 7? It is the atmosphere mainly that apparently causes the canals, if visible, to be resolvable. In his article on Mars, some pages of which are referred to above, Mr. Antoniadi does not describe the quality of the air through which he observed. It may be clear, but not steady enough to permit the sharpest detail to show as such. In passing from a large refractor to a much larger one, the observer is rather far more deceived by the state of the atmosphere than by the delicate character of the canals themselves. It may be remembered that, under ordinary conditions, a large instrument for visual observations is more affected by atmospheric disturbances than in a smaller one: the larger the instrument and, therefore, the higher the power, so much better must be the conditions of the air at and above the place of observation.

Los Angeles, Hollywood, Cal.

MONTHLY REPORT ON MARS.—No. 4.

WILLIAM H. PICKERING.

During the past month from January 16 to February 15 the northern polar cap ceased to retreat. The mean of six observations made between February 12 and 16 gave a latitude for its southern boundary of 68°.5 or practically the same as that found in the middle of January. This would seem to imply that the remaining area north of this latitude is of considerable thickness and therefore melts slowly. Three of the four polar marshes became much fainter, and apparently dried up, indicating that the water supply was diminishing. Unfortunately our double-image prism did not arrive until February 17, and the places formerly occupied by the marshes, examined since that date, have shown no polarization, but when they were dark blue in color there is no doubt but that the light coming from them was polarized as had been the case at two previous oppositions.

On January 13 Professor Lowell reported that the Martian southern cap was beginning in stippled patches of hoarfrost, between longitudes 30° and 60°. Our own next view of this region was on February 7, when it was occupied by a cloud 1200 miles in length. The cloudy area increased in size the next night to 1800 miles, but two nights later was again smaller, measuring 1500 miles. February 12 it had entirely disappeared. The following night all the south polar regions were recorded as very dark, with no trace of cloud. February 14 a crescent of haze lay along the whole length of the limb and part of the terminator, extending half-way to the center of the disk, entirely concealing the polar regions. After this the area in question passed around to the other side of the planet, and we saw no more of it. We are quite clear however that there was no hoarfrost or permanent snow area there on either February 12 or 13. The writer does not believe that the hoarfrost is ever seen far from the sunrise terminator, and he would suggest that what Professor Lowell interprets as hoarfrost is described here as cloud. The appearance noted here has a white pearly lustre, clearly fainter than the snow at the north pole, but brighter and much whiter than the desert areas of the planet.

White cloud is occasionally seen in the equatorial regions close to the limb, but when it gets nearer the center of the disk it turns yellow owing doubtless, as previously stated, to its thinness, and to the fact that we see the soil between separated small clouds. Our own cumulus clouds often have a bluish tint, even near thin centers, when they are forming or dissolving, and are therefore thin enough for us to see our blue sky through them.

It is the writer's impression that the meteorology of Mars resembles very closely that of the earth, much more closely than has heretofore been supposed. Clouds are numerous on both planets but they are more so in the daytime with us, and possess greater density. It is believed for theoretical reasons that the northerly and southerly components of their winds are more marked than ours, that their daily range of temperature is greater, and that their precipitation usually occurs at night, but except in these respects the meteorology of the two planets is practically identical.

The writer has introduced the custom of entering on his drawings certain numbers, indicating the brightness of the areas observed. He does not know whether this plan has been previously used as a regular custom by others, but recommends it to their attention. It is what has been done by selenographers in their lunar observations for years, and is generally approved. On the writer's scale the polar snows are marked 10, and the very blackest areas 1. Most of the *maria* are about 3, most of the deserts 6 to 7, and the polar clouds usually 8.

For many years Martian observers have been in the habit of reporting marked changes as occasionally occurring upon the planet, but the writer believes that a considerable proportion of these, perhaps a third, were due simply to shifting clouds. Thus the numerous and marked changes in size of the southern polar cap at this opposition are almost certainly due to nothing more complex than the formation and dissolution of cloud areas. The sudden appearance of two lakes and four canals in the Protei Regio on December 31, where on the previous night only a whitish area was visible, was presumably due to the clearing away of clouds. Possibly the fact that certain narrow canals were seen south of the Sabaeus in January, which were not seen on February 14 or 16, though near the center of the disk, with seeing 12 and 10, is due to their having been hidden by invisible, because partially transparent, cloud masses. The writer believes that the disappearance and reappearance of Margaritifer Sinus between February 8 and 14 was due to the same cause. Whether its first appearance in the latter part of November will bear the same explanation is by no means so certain.

On the other hand the formation of the four marshes surrounding the north polar cap, the formation of a dark area bounding it, some 900 miles in width in one place, and its subsequent disappearance, are clearly due to some other cause. The appearance of the whole region about Solis Lacus as of a uniform grey tint in August, and also at the end of November, and the beginning of December, and its subsequent clearing up at the end of the latter month, when the dark areas were surrounded and intermixed with bright areas, so as to give the region its customary aspect, could not possibly be due to the clearing away of clouds,—unless indeed we assume the latter to have been of a dark grey tint, like the *maria* themselves. This seems to have been a case where the vegetation, at first grey, died or turned yellow in certain areas. The Martian date was April 3, which for the southern hemishere would correspond to October 3 for us, in the northern hemisphere of the earth.

In the last report attention was called to the gradual shifting in latitude of the northern boundary of the dark regions of the planet in certain places. It is thought that some statistics of this change may now be of interest. In Table I three different longitudes 315°, 185°, and 130° are considered. The measures were all made from drawings, and in the first two columns of each section the date and central meridian are given. The last column gives the measured latitude of the boundary line in the longitude indicated at the head of the column.

In the first longitude considered little change occurred in the latitude after October 30, when a slight increase was observed. In the second longitude no obvious change occurred between September 2 and December 23. After that the latitude also increased. A comparison of the figures in these two columns will give one an idea of the accuracy to be

TABLE I.

CHANGE IN LATITUDE OF THE BORDER OF THE DARK AREAS.

1913-4	Central 315°		1913-4	Central 185°		1913-4	Central 130°	
	°			°			°	
Aug. 14	4	−6	July 27	180	−15	Aug. 6	92	+12
Sept. 17	0	−5	Sept. 2	183	−25	Oct. 12	160	−33
Oct. 30	346	−16	Oct. 12	160	−28	Dec. 19	162	−47
Nov. 30	0	−20	Nov. 17	187	−23	" 25	125	−44
Dec. 2	4	−25	Dec. 16	192	−22	Feb. 1	150	−60
" 3	346	−15	" 17	185	−25			
Jan. 4	5	−20	" 18	177	−28			
" 6	351	−20	" 19	162	−25			
" 10	342	−18	" 22	168	−23			
Feb. 12	350	−16	" 23	172	−23			
" 14	537	−25	Jan. 21	184	−34			
			" 27	163	−28			
			Feb. 1	158	−31			

expected from this method of measurement. Thus during the interval when no change is thought to have taken place the latitude and average deviation of the nine results in the first section is $-19°.4 \pm 2°.9$; of the nine results in the second section $-24°.7 \pm 1°.7$. The latitudes given by Schiaparelli are −12° and −30° respectively. According to the map of Lau referred to in Report No. 3, they are −15° and 22°. The results by both of these authorities were obtained with a micrometer. It does not seem possible to explain the large deviations between them as due merely to accidental errors. The stations selected, especially the first one, Hammonis Cornu, might be supposed to be fairly constant in position. During the January, February presentation, the writer's determination of the mean latitude of the second station 31°, agrees very well with Schiaparelli, but the earlier measures agree better with Lau.

When we come to the third station, in longitude 130°, the change in latitude is so marked and so regular, that it is obviously due to a continuous alteration of the boundary line. Indeed this is shown by the most casual examination of the drawings. The Martian dates corresponding to the first and last observations of this region, August 6 and February 1, are January 17 and April 19. Since the course traversed by the station (if station is the proper word to use in speaking of the survey of such a region), lies chiefly in the southern hemisphere of Mars, the corresponding dates for us in the northern hemisphere of the earth, would be from the middle of July to the middle of October. That is the gradual change from green or grey to yellow occurred in their autumn. It would thus appear that the great yellow plains of Mars, which are sometimes red and sometimes yellow, but usually light-colored, may be spoken of as deserts only for purposes of convenience, and because we cannot tell where the boundary line between the yellow sand and the yellow vegetation really lies.

We should note that this gradual change in latitude is quite different from the change in color of Libya. When Libya is light colored the northern boundary of the *mare* in that longitude is in latitude $-10°$. When Libya is dark colored the latitude is $+10°$, but the whole area which is enclosed by canals, changes color at the same time, the latitude is either $+10°$ or $-10°$, never any intermediate value.

But it is not merely the vegetation whose boundary lines shift about over the surface of the planet. In Table II are given the latitudes and longitudes of the northern and southern ends of the two marshes which have been previously referred to as the twin bays on the southern boundary of the northern polar cap. In some of the drawings only one bay is shown, for sometimes one and sometimes the other is too near to the limb or terminator. A comparison of the upper and lower line of

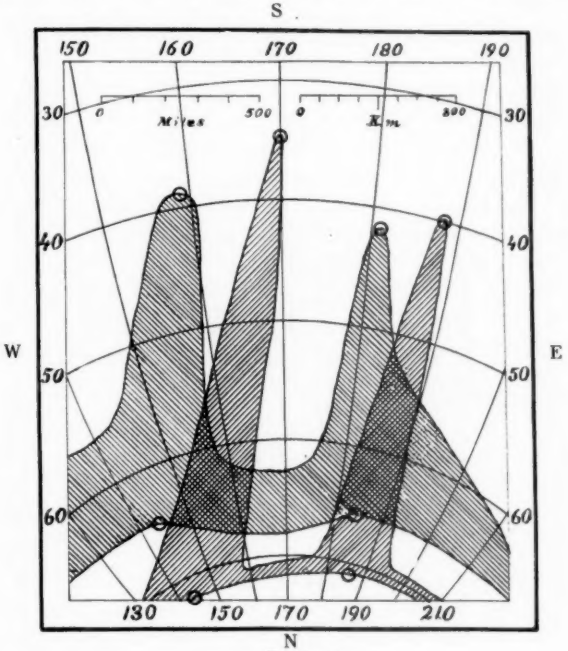


FIGURE 1.

means shows what changes have taken place between the December and January presentations. In both cases it will be noticed that the northern ends have retreated northerly with the retreating snow, while the southern ends have advanced southerly, thus lengthening the bays at both ends. But the most interesting feature consists in the change

in the longitude. We showed in the last report the reason why the clouds rising from all the marshes were observed to drift to the astronomical east, or following side, as they traveled southerly. We now find that the marshes themselves drift more slowly in the same direction. That is, the water evaporated from them by day is deposited from the clouds at night, causing the marsh to slowly advance southerly and easterly as we have seen. Also we notice that the southerly ends advance much more rapidly to the east than the northerly ones, which is what we should expect.

These changes are more readily followed by means of the map shown in Figure 1, where the shade lines inclined to the right represent the December, and those inclined to the left the January positions, of the two bays. While these shifting marshes are certainly not canals, yet in some respects they resemble them, and the question might be raised are we not now looking on at the same process employed in canal construction, the chief difference being that in this case it is done on so large a scale that we are able to follow it.

TABLE II

CHANGE IN LOCATION OF THE TWIN BAYS.

	Bay A				Bay B			
	N		S		N		S	
1913-4 Cent.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.
	°	°	°	°	°	°	°	°
Dec. 16 192	+65	148	41	160	+68	184	+36	180
17 185			41	160	67	185	46	183
18 177			44	160	66	189	44	185
19 162			43	156	64	184	45	174
22 168	+64	148	41	158	65	186	40	180
23 172			47	160	66	182	46	184
25 125	60	145	36	160				
29 155	69	140	39	158	69	175	40	180
Mean	65	144	41	159	66	184	42	181
Jan. 21 184			34	172	70	184	35	188
28 163	71	147	37	165			47	193
Feb. 1 150	72	148	32	176				
158	72	138	38	168	72	188	38	184
Mean	72	144	35	170	71	182	40	188

The two obvious objections to this hypothesis are the great relative length of some of the canals, and the fact that the same region may one year be traversed by a single clearly maked canal running north and south, and the next year at the same season by a single canal running east and west. It is easy to reply that the Martians can deposit moisture from a saturated atmosphere wherever they please, by liberating electrons or something of that sort, on which the vapor can condense, but we haven't got as far as that ourselves yet, except as a laboratory experiment, and we don't know that there are any Martians. So we had best leave that question in abeyance.

Returning from this brief hypothetical digression to the facts of observation, the question may now be asked are we sure that any of the dark markings are fixed features of the planet. The writer believes that the chief canals do not shift laterally, at least to any great extent, and that the lakes are also fairly fixed in location. Fastigium Aryn, the point from which all Martian longitudes are reckoned, is a light colored point lying between two bays. The point is sometimes drawn long and narrow and sometimes short and broad. Its axis is sometimes represented as lying due north and south, and sometimes with a position angle of $-15° \pm$. The latter position is undoubtedly sometimes correct, and the length undoubtedly varies, so it is highly probable that the position of its end or point varies somewhat in longitude. The variation is so small however that it is of little consequence for our present purposes.

Professor Lowell and the writer both independently found from micrometric measurements, that the Martian meridian transited several minutes ahead of time this year. Since Aryn itself was not visible, presumably in both cases points in its immediate vicinity were selected for the observation. The writer used the Edom promontory, longitude 356°. It is quite possible that the longitude of these secondary points may themselves vary somewhat,—hardly enough to vitiate the fact of the deviation, but enough to invalidate its accuracy. It is therefore most desirable that several observers should repeat the observation at the next opposition, if Aryn is then visible. This may well be the case, as the opposition will occur appreciably later in the Martian season then, than it did this year, so that Aryn will have had time to develop. Aryn was certainly not visible February 14, when within 23° of the center of the disk, with seeing 12. $\odot = 35°.2$. Equivalent Martian date April 24.

A notable change in darkness occurred at the northern end of the Syrtis major this year, a region that is often very dark, sometimes blue, and sometimes brown. A dark segment-shaped marking 1100 miles in length was observed January 15, which had been fainter, larger, and more ill-defined at the previous presentation. Two days later a dark bay 500 miles in length was thrown out along the line of Nepenthes. See Fig. 2. The following day this was unchanged, but when next seen, in February, the whole region had faded materially, no trace of the segment or the bay being visible.

It will perhaps be of interest to study the change in color that accompanied this change in darkness. On December 8, 10, and 12 the region concerned is described and painted as green and greenish grey. January 11 it is described as "Grey, neither green nor brown." January 12, Bluish or greenish grey. January 15, "Grey. Neither brown, green,

nor blue, but the region following is greenish". January 17, "Very blue tonight." January 18, Very blue or green. February 14, Grey. February 16, Greyish green.

It will be noticed that January 15 the region is clearly described as grey, but on the addition to its area of the large bay two days later, its color changed to "very blue." It appears to the writer that this blue color can have been due only to water. This same color has been noted in this same region by others, notably by Molesworth in 1903, as well as by the writer on previous occasions. This region is then a marsh, like the ones surrounding the polar cap, but it is the only one to which the water was transported over a great distance, some 2000 miles. Moreover the water did not remain there for any great length of time; less than 30 days. A local darkening December 10 leads us to believe that there may have been an earlier deposit in this region, not observed at this station.

The two dark lines connecting it with the polar cap were, with the possible exception of Cerberus, much the most strongly marked canals that were observed during this opposition. January 15 and 17 they measured some 200 miles in width, January 18 but 100 to 150. On February 24 the following one Nilosyrtis was but a few miles in breadth. It would certainly seem that the great increase in size of the dark spot and its change of color on January 17 had some connection with the narrowing of the canals the next day. It also seems as if these two very marked and sharply bordered canals differed in their functions from the fainter ones, with more hazy borders, found in other parts of the planet.

The phenomenon observed is the exact counterpart of that recorded by Professor Douglass and the writer July 17, 1892, when the water from the southern polar cap discharged through Pandorae Fretum and the Mare Australe into this very same region (Astronomy and Astro-Physics 1892 **11**, 668.) The two canals concerned on that occasion were recorded as of 150 miles in width, and sharply defined. Immediately after the temporary enlargement of the swamp, along Nepenthes, see Fig. 3, which is described as blue in color, the canals faded, one narrowed and the other, the following one, disappeared. In the present instance the two canals joined the bluish marsh known as Boreosyrtis with the marsh in the Syrtis Major. In 1892 they connected a long dark narrow cleft in the polar cap with this marsh. The heliocentric longitude of Mars at the time of the first event was 301°, at the second 110°, difference 191°. That is they occurred at very nearly opposite seasons of the year, the corresponding Martian dates being October 22, and April 12. The two canals which faded and narrowed in each case are marked by arrows, indicating the course of the vapor which it is

thought condensed to produce the marsh and its extension. In 1892 both canals started at the right hand end of the snow cap. By July 23, the shape of the marsh was very like that shown in Fig. 2, but in August its size was again further reduced. Why two canals should be

FIGURE 2.

FIGURE 3.

involved in both cases seems a little surprising, but possibly vapor coming along the two routes met and produced an especially heavy downpour at their junction. It is believed, although it is by no means certain, that the Syrtis marsh is filled twice every Martian year. Whether two canals are always concerned in the filling is yet to be determined.

Sabaeus like the Syrtis Major has sometimes been observed to be of a deep blue color. This has not been recorded this year however. When it first developed upon November 30, and again on December 3, it was described as grey. At its next return January 6 its color was a chocolate brown, and this color it retained through February 13, when it is recorded as "clearly brown". February 14 it is described as having "a trace of brown," but February 16 the record reads "Sabaeus grey, not brown." This is our last note concerning it. Cerberus has constantly been recorded as brown this year, and was so at last accounts, these being the only two areas on the planet where this color has been observed at this opposition. The greens of the southern *maria* which have hitherto been so conspicuous, are now gradually fading into greys with the approach of winter, in those portions of the planet where they have not already turned yellow. Indeed we see that on Mars as on the earth different kinds of vegetation act differently with the advance of the seasons, and it is possible that some future astronomer may even develop a botany of Mars, as we are now trying to develop its meteorology.

Turning now to the observational side of our work, Professor Lowell has long claimed that there were advantages in using a reduced aperture on Mars, when the seeing was not at its best, and I believe in practice he seldom uses over 18 inches, and often less. Many years ago the

writer found that with the quality of seeing usually prevailing at Cambridge, better photographs of the moon could be obtained with a 4-inch aperture than with either a larger or smaller size. On one occasion recently, in January, when the seeing here was exceptionally bad, about 3, the planet being at an altitude of 30°, it was found that just as much could be seen with the 3-inch finder, and a magnification of 180, as was visible with the 11-inch, and powers of either 330 or 660. As a result of experiment we find that when the seeing here gets as bad as 6, which is about the best we have in Cambridge, that better results are obtained if we stop our aperture down to 8 inches. Certainly nothing could be done with a 30 or 40-inch lens under the circumstances.

In practice however when the seeing gets as bad as that, unless something of especial interest is happening, we seldom observe at all, as it is a mere waste of time.

The following canals have been recorded here this past month:

Jan. 17. **5** Nilosyrtis, Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous (L).

Jan. 18. **5** Nilosyrtis, Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous, Cerberus, Hyblaeus, Styx.

Jan. 20. **4** Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous, Cerberus, Hyblaeus, Styx, Aesacus, Anian, Hades, Orcus.

Jan. 21. **3** Cerberus, Hades, Pallene (L).

Jan. 27. **3** Cerberus.

Feb. 1. **3** Cerberus, Hades, Pallene, Trais (L) (?), Gigas (?).

Feb. 5. **2** Agathodaemon, Daemon, Nectar, Hyscus (L), Eumenides, Chrysorrhoas, Phlegethon.

Feb. 7. **2** Agathodaemon, Daemon, Nectar.

Feb. 8. **1** Ganges.

Feb. 12. **1** Ganges.

Feb, 14. **6** Protonilus.

The following Table of Data is arranged like those published in the preceding reports.

TABLE OF DATA.

No.	1914.	⊙	M.D.	Long.	Lat.	Sun	Diam.	Seeing
		°		°	°	°	″	
55	Jan. 17	22.7	Apr. 12	284	+3	+9	14.3	11
56	"	"	"	306	"	"	"	7
57	18	23.1	"	240	+2	"	"	10
58	"	"	"	302	"	"	"	6
59	20	24.1	13	222	"	"	14.1	8-10
60	21	24.6	"	184	"	+10	14.0	4
61	27	27.3	16	163	"	+11	13.5	6
62	Feb. 1	29.6	19	150	+1	+12	12.8	12
63	"	"	"	158	"	"	"	10
64	5	31.4	20	104	"	"	12.4	8
65	7	32.3	21	74	"	"	12.2	10
66	8	32.8	22	42	"	+13	12.0	10-6
67	10	33.7	23	50	"	"	11.8	6
68	12	34.6	24	350	"	"	11.6	6-9
69	"	"	"	38	"	"	"	6
70	14	35.2	"	337	"	+14	11.4	12-10
71	"	"	"	29	"	"	"	7-9

Referring to the twin bays at the edge of the northern polar cap, one of our European correspondents, M. Jarry Desloges has kindly furnished the following information:—

They were first seen in November. On November 5 and 8 they appeared rounded, but on November 9 vaguely triangular. November 10 they were again rounded, but November 15 large and triangular. November 17 they were pale and on the limb. December 9 and 12 they were triangular. December 13 they were measured, and were observed every night until December 18. They were observed again on the nights of January 16 and 21, when they were still triangular, and their southern ends were now united with Titan. The writer would remark that the change from the rounded to the triangular form must not necessarily be attributed to a change in the quality of the seeing, for sometimes he has noted that one bay is fainter, and sometimes the other, and that they change from night to night. M. Desloges further states that something unusual was observed between them at both of his observatories, but does not mention what it was. Nothing but a small cloud was noticed here, on December 19 to 23, but possibly some of our readers can supply this deficiency, and thus corroborate his observation.

NOTE ON THREE NEW BINARIES.

STORRS B. BARRETT.

In his paper on "The Radial Velocities of Twenty-six Stars", Jordan* published measures of two stars which had been under my observation also, at Yerkes Observatory. These are *21 Lyncis* and *6 Comae*. The spectrum of the former contains some excellent lines and a variation of 15 km. on eight plates indicates clearly a binary. The range is from +23 km. to +38 km. The four plates taken at Allegheny gave values between +20.8 and +28.4 km.

The lines of *6 Comae* appear poor on many plates, but on the best ones it is possible, under low powers, to measure fine lines, often in pairs. The Allegheny values from six plates range from −3 km. to +15 km., with an average +5 km. which probably represents the center of gravity of the components, the stronger of which gives a range of from −50 km. to +150 km. on my plates taken in the years 1909-1911.

* *Pub. Allegheny Observatory*, **2**, *121, 1911.*

In the spring of 1913 twelve plates were taken and measured at the Yerkes Observatory of the fifth magnitude star *2 Monocerotis*. It was at once seen to be a binary. The star is of interest because of its range of 120 km., its good lines and its regular period of 9.36 days, which invite an investigation of its orbit. A velocity of recession of about 30 km. is indicated for the system. The lines of the second component are probably faintly seen on some of the plates. Detailed measures of these three stars will be published later.

Yerkes Observatory,
March 18, 1914.

PLANET NOTES FOR MAY, 1914.

The sun will move from about 15° north declination to nearly 22° north during the month, and by the end of May will again have reached almost its farthest point north. Its path eastward will lie from Aries into Taurus, and by the end of the month the sun will be very near the Pleiades and Aldebaran.

The phases of the moon for this month are as follows:

First Quarter	May	2	at 12 P.M.	C. S. T.
Full Moon		9	" 3 P.M.	"
Last Quarter		16	" 4 P.M.	"
New Moon		24	" 9 P.M.	"

Mercury will be invisible throughout the month. It will move eastward faster than the sun and will pass behind the sun from the earth on May 16. It happens that at this time it will also be at about its nearest point to the sun in actual distance. Toward the end of the month it will be approachiug a position of greatest eastern elongation, so that in the early part of June it will be visible in the west after sunset.

Venus will be visible in the west in the evening. It will be a little higher in the sky each day at sunset than the day before. It will be a very brilliant object and will far exceed any star in brightness. It will therefore be an object of great interest both for the naked eye and for the telescope. It will be nearest the sun in actual distance on May 27.

Mars will continue to be in a very good position for observation. It will cross the meridian a little while before sunset throughout the month. It will be moving east and south. At the middle of the month it will be in the constellation Cancer, and will form approximately an isosceles triangle with Procyon and Regulus.

Jupiter will be in quadrature, ninety degrees west of the sun, on May 12. On and near this date it will therefore be very near the meridian at sunrise. It will however be fifteen degrees south of the equator. It will be moving eastward slowly in the constellation Capricornus,

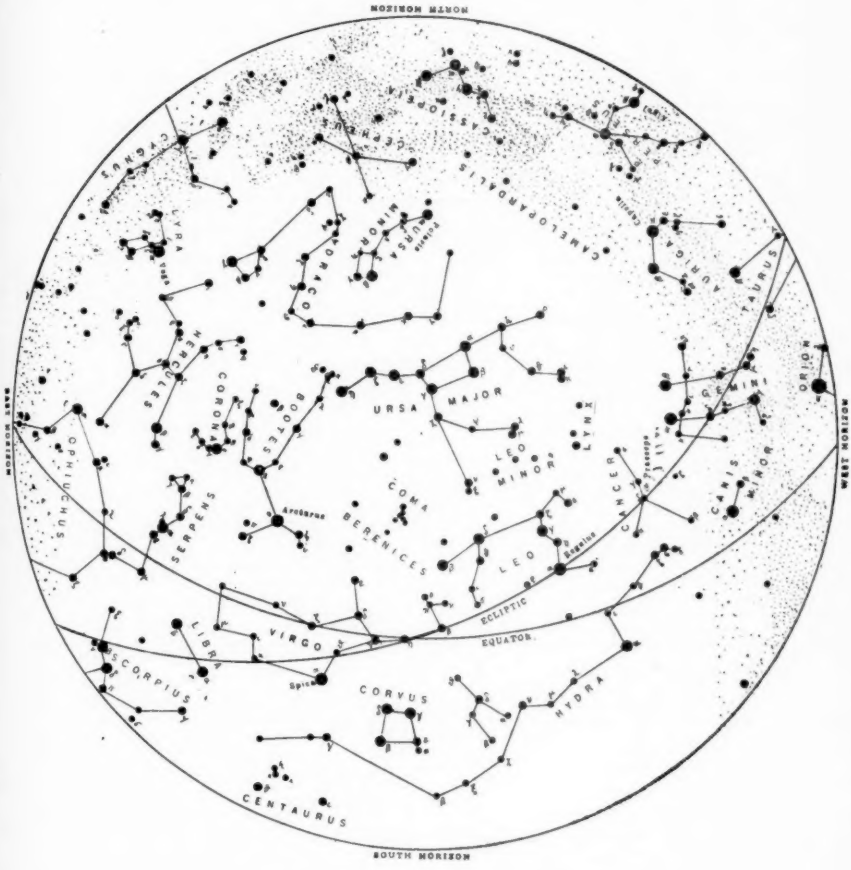
Saturn will be to near the sun to be seen during the month. It will be in conjunction with the sun early in June.

Uranus will be rather near in the sky to Jupiter. It will be in quadrature on May 2. It will be moving slowly back and forth in Capricornus.

Neptune will still be visible in the west after sunset. By the end of the month it will set three hours and a half after the sun.

Occultations Visible at Washington.

Date 1914		Star's Name	Magnitude	IMMERSION. Washington M.T. h	m	Angle f'm N. °	EMERSION. Washington M.T. h	m	Angle f'm N. °	Duration h	m
May	1	5 B. Cancri	6.4	9	47	139	10	42	270	0	55
	8	43 H. Virginis	5.5	7	55	63	8	27	4	0	32
	8	231 G. Virginis	6.4	8	46	94	9	46	335	1	0
	8	236 G. Virginis	5.7	9	46	63	10	22	5	0	36
	10	τ Scorpii	2.9	15	44	133	16	40	235	0	56
	16	42 Aquarii	5.5	13	42	91	14	46	217	1	4
	17	81 Aquarii	6.4	14	15	51	15	24	251	1	9
	28	κ Geminorum	3.7	8	5	119	9	3	285	0	58



THE CONSTELLATIONS AT 9:00 P. M. MAY 1, 1914.

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME

1914	h	m		1914	h	m	
May 1	13	18	II Tr. In.	May 17	12	48	III Sh. Eg.
1	13	30	II Sh. Eg.	17	13	33	I Sh. Eg.
1	14	17	I Tr. In.	17	14	33	III Tr. In.
1	15	18	I Sh. Eg.	17	14	54	I Tr. Eg.
2	13	50	I Oc. Re.	19	15	0	IV Tr. Eg.
6	15	19	III Ec. Dis.	24	13	5	III Sh. In.
8	13	11	II Sh. In.	24	13	6	I Sh. In.
8	14	51	I Sh. In.	24	13	7	II Ec. Dis.
10	13	1	I Tr. Eg.	24	14	26	I Tr. In.
10	13	32	II Oc. Re.	25	14	0	I Oc. Re.
10	14	18	III Tr. Eg.	26	13	21	II Tr. Eg.
16	14	0	I Ec. Dis.	28	12	14	III Oc. Re.
17	12	34	I Tr. In.	31	14	59	I Sh. In.

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh.. transit of the shadow.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1914.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900 h m	Decl. 1900 ° ′	Magn.
X Androm.	0 10.8	+46 27	12.9	R Trianguli	2 31.0	+33 50	9.1*d*
T Androm.	17.2	+26 26	11.0 *i*	W Persei	43.2	+56 34	9.4
T Cassiop.	17.8	+55 14	9.6	U Arietis	3 5.5	+14 25	8.5 *i*
R Androm.	18.8	+38 1	7.2 *i*	X Ceti	14.3	— 1 26	10.6*d*
S Ceti	19.0	— 9 53	<11.0	Y Persei	20.9	+43 50	9.5
Y Cephei	31.3	+79 48	10.0	R Persei	23.7	+35 20	10.1*d*
U Cassiop.	40.8	+47 43	10.6 *i*	V Eridani	59.8	—16 0	9.2
V Androm	44.6	+35 6	<12.0	R Tauri	4 22.8	+ 9 56	<10.0
RR Androm.	45.9	+33 50	11.7*d*	W Tauri	22.2	+15 49	10.7*d*
RV Cassiop.	47.1	+46 53	12.2*d*	S Tauri	23.7	+ 9 44	<10.0
W Cassiop.	49.0	+58 1	9.8	T Camelop.	30.4	+65 57	9.2 *i*
U Androm.	1 9.8	+40 11	11.8*d*	– Tauri	32.8	+ 8 9	9.5
– Androm.	10.4	+41 12	<13.0	X Camelop.	32.6	+74 56	11.0
S Piscium	12.4	+ 8 24	<12.0	R Orionis	53.6	+ 7 59	9.8 *i*
S Cassiop.	12.3	+72 5	13.1*d*	V Orionis	5 0.8	+ 3 58	<12.0
RZ Persei	23.6	+50 20	13.5	R Aurigae	9.2	+53 28	8.3
R Piscium	25.5	+ 2 22	11.1	S Aurigae	20.5	+34 4	9.3
RU Androm.	32.8	+38 10	<13.0	W Aurigae	20.1	+36 49	10.8*d*
Y Androm.	33.7	+38 50	12.2*d*	S Orionis	24.1	— 4 46	12.8
X Cassiop.	49.8	+58 46	10.6	T Orionis	30.9	— 5 32	10.0
U Persei	53.0	+54 20	8.0	SU Tauri	43.2	+19 2	<14.0
R Arietis	2 10.4	+24 35	7.9	Z Tauri	46.7	+15 46	13.4
W Androm.	11.2	+43 50	9.0*d*	RU Tauri	46.9	+15 57	<12.0
T Persei	12.2	+58 30	8.8	U Orionis	49.9	+20 10	10.2
Z Cephei	12.8	+81 13	<13.0	V Camelop.	49.4	+74 30	<14.0
o Ceti	14.3	— 3 26	3.1	Z Aurigae	53.6	+53 18	10.6
S Persei	15.7	+58 8	10.9	X Aurigae	6 4.4	+50 15	8.7
RR Persei	21.7	+50 49	13.8	V Aurigae	16.5	+47 45	9.7*d*
U Ceti	28.9	—13 35	<10.1	V Monoc.	17.7	— 2 9	6.6
RR Cephei	29.4	+80 42	11.9*d*	U Lyncis	31.8	+59 57	13.7

Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1914.—Continued.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Dec. 1900.	Magn.
	h m	° ′			h m	° ′	
S Lyncis	6 35.9	+58 0	13.8	R Camelop.	14 25.1	+84 17	8.3
X Gemin.	40.7	+30 23	10.0 *i*	RU Librae	15 27.7	−14 59	<13.0
Nova. Gem. No. 2	45.5	+32 17	11.0	S Urs. Min.	33.4	+78 58	12.2
X Monoc.	52.4	— 8 56	7.8	W Cor. Bor.	16 11.8	+38 3	11.8*d*
R Lyncis	53.0	+55 28	7.6	R Urs. Min.	31.3	+72 28	10.2
V Can. Min.	7 1.5	+ 9 2	13.1*d*	R Draconis	32.4	+66 58	9.0 *i*
R Gemin.	1.3	+22 52	12.4*d*	T Draconis	17 54.8	+58 14	10.9
R Can. Min.	3.2	+10 11	10.5*d*	V Draconis	56.3	+54 53	13.5
RR Monoc.	12.4	+ 1 17	11.2	W Draconis	18 5.4	+65 56	13.9
S Can. Min.	27.3	+ 8 32	7.8*d*	X Draconis	6.8	+66 8	13.0 *i*
U Can.Min.	35.9	+ 8 37	11.8*d*	SV Draconis	31.2	+49 18	10.5*d*
R Cancri	8 11.0	+12 2	10.4 *i*	RY Lyrae	41.2	+34 34	11.5 i
T Lyncis	16.4	+33 51	11.2	Z Lyrae	56.0	+34 49	11.4*d*
RT Hydrae	24.7	— 5 59	8.1	V Lyrae	19 5.2	+29 30	9.2
U Cancri	30.0	+19 14	9.4	S Lyrae	9.1	+25 50	13.0*d*
W Cancri	9 4.0	+25 39	13.5	U Draconis	9.9	+67 7	12.0 *i*
Y Draconis	31.1	+78 18	14.4	TZ Cygni	13.4	+50 0	11.6
R Leo. Min.	39.6	+34 58	9.0*d*	U Lyrae	16.6	+37 42	9.3
R Leonis	42.2	+11 54	6.8*d*	TU Cygni	43.3	+48 49	10.8*d*
R Urs. Maj.	10 37.6	+69 18	12.4 *i*	V Sagittae	20 15.8	+20 47	11.6
V Hydrae	46.8	−20 43	7.0	ST Cygni	29.9	+54 38	11.8*d*
W Leonis	48.4	+14 15	<13.0	TW Cygni	21 1.8	+29 0	<13.0
T Urs. Maj.	12 31.8	+60 2	11.6 *i*	X Cephei	3.6	+82 40	<13.0
R Virginis	33.4	+ 7 32	9.3*d*	T Cephei	8.2	+68 5	9.4*d*
RS Urs. Maj.	34.4	+59 2	13.5	S Cephei	36.5	+78 10	11.7*d*
S Urs. Maj.	39.6	+61 38	8.0	V Cassiop.	23 7.4	+59 8	11.8*d*
T Urs. Min.	13 32.6	+73 56	12.2*d*	ST Androm.	33.8	+35 13	11.0
R Can. Ven.	44.6	+40 2	8.0 *i*	Z Cassiop.	39.7	+56 2	12.2
U Urs. Min.	14 15.1	+67 15	8.8	R Cassiop.	53.3	+50 50	11.8
S Bootis	19.5	+54 16	9.1 *i*	Y Cassiop.	58.2	+55 7	11.2*d*
RS Virginis	22.3	+ 5 8	13.7	SV Androm.	59.2	+39 33	12.6
V Bootis	25.7	+39 18	9.9 *i*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, N. Bruseth, A. B. Burbeck, E. Gray S. C.Hunter, M. W. Jacobs, Jr., J. B. Lacchini, F. C. Leonard, C. Y. McAteer, W. T. Olcott, P. G. O'Reilly, E. W. Putnam, C. Richter, E. Padova, H. M. Swartz, D. Todd, H. W. Vrooman, I. E. Woods, M. Yamasaki, and A. S. Young.

The Variation of two Stars, announced last year as 8.1913 Persei and 18.1913 Lyrae, is verified in a note in *A.N.* 4715 by S. Enebo. The approximate elements of these stars in order are given as follows:

$$\text{Max.} = 2419351 + 228^{d}\,E$$
$$\text{Max.} = 2419677 + 227\ E$$

Both of these stars vary approximately from 10^{m} to $12^{m}.5$.

Minima of Variable Stars of Short Period.

[Calculated by May E. Abbott, at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1914 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			21 21					
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	5 22;	13 15;	21 7;	28 23				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	5 6;	12 16;	20 2;	27 13				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	4 12;	11 23;	19 11;	26 22				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	5 4;	11 7;	23 12;	29 15				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 0:	9 3;	16 7					
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	2 5;	9 1;	22 19;	29 16				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	2 3;	9 7;	23 15;	30 19				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	2 14;	11 9;	20 4;	28 22				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 9;	14 6;	22 6;	30 5				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	4 23							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 6;	9 23;	21 10;	27 4				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	1 12;	8 7;	21 21;	28 16				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	4 15;	12 12;	20 10;	28 8				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	5 1;	13 8;	21 16;	29 23				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	2 17;	10 14;	18 12;	26 9				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	2 16;	15 21;	29 2					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4 9;	13 20;	23 7					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	4 22;	17 8;	29 18					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	5 17;	12 9;	19 1;	25 17				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2 4;	7 14;	18 12;	29 10				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3 5;	9 6;	21 7;	27 7				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	7 20;	16 12;	25 4					
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9		10 7;	20 16;	31 2				
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 6;	12 6;	20 7;	28 7				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 2;	6 19;	18 6;	29 18				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	1 5;	6 19;	18 0;	29 5				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 18;	13 23;	22 4;	30 9				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	4 16;	12 7;	19 22;	27 13				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		12 4;	24 9					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	7 21;	15 1;	22 5;	29 9				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	3 7;	12 9;	21 11;	30 13				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	3 18;	13 1;	22 8;	31 16				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3		10 3;	20 1;	29 23				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	7 0;	15 10;	23 20					
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	3 0;	9 10;	22 7;	28 17				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	4 8;	11 14;	18 21;	26 3				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5 9;	13 12;	21 15;	29 17				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	1 8;	10 20;	20 7;	29 19				
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	9 3;	18 6;	27 10					
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	6 3;	12 15;	19 2;	25 14				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	1 14;	7 12;	19 9;	31 6				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	1 23;	10 10;	18 20;	27 6				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	7 1;	16 8;	25 14					
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	7 7;	13 21;	20 12;	27 2				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 19;	17 14;	26 10					
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	2 4;	9 12;	24 4;	31 12				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	2 2;	8 21;	22 11;	29 6				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	8 11;	15 23;	23 11;	30 23				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6 18;	14 4;	21 14;	29 1				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 0;	9 0;	22 23;	29 22				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	2 10;	9 8;	23 3;	30 1				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	9 1;	17 11;	25 21					
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	6 7;	13 22;	21 14;	29 6				

Minima of Variable Stars of Short Period.—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of minima in 1914 May
	h m	° ′		d h	d h d h d h d h d h
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	2 1; 9 9; 24 1; 31 9
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	7 10; 15 16; 23 23
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	2 19; 11 15; 20 11; 29 8
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	7 11; 17 4; 28 5
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	4 11; 11 6; 24 21; 31 16
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 6; 14 15; 23 1; 31 10
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	3 23; 10 3; 22 10; 28 14
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 21; 12 2; 19 7; 26 12
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	2 2; 9 11; 24 5; 31 14
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 3; 9 7; 17 12; 25 16
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	5 11; 13 0; 20 13; 28 2
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 11; 12 5; 19 23; 27 17
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	8 8; 16 8; 24 7
WX Sagittae	53.6	—17 24	9.2—10.8	2 03.1	1 6; 9 19; 18 7; 26 20
WY Sagittae	17 54.9	—23 1	9.5—10.6	4 16.0	3 7; 12 16; 22 0; 31 8
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	1 20; 12 4; 22 12
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	2 12; 9 18; 24 6; 31 12
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	6 12; 13 10; 20 8; 27 6
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	6 20; 21 23
RZ Draconis	21.8	+ 58 50	9.5—10.2	0 13.2	7 18; 16 0; 24 6
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 23; 13 20; 22 18; 31 16
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	4 22; 13 5; 21 13; 29 20
RR Draconis	40.8	+62 34	9.3—13	2 19.9	1 3; 9 14; 18 2; 26 14
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 0; 7 16; 20 23; 27 14
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	10 4; 23 1
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	1 15; 11 4; 20 17; 30 6
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	7 18; 15 8; 22 22; 30 12
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	4 18; 11 22; 19 3; 26 8
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	4 3; 13 2; 22 1; 31 0
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	4 11; 11 6; 24 18; 31 12
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	1 4; 8 13; 23 6; 30 15
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 11; 9 17; 20 5; 30 16
UZ Draconis	26.1	+ 68 44	9.0— 9.8	1 15.1	1 9; 7 21; 20 22; 27 11
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	1 16; 7 16; 19 16; 31 17
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	6 5; 12 20; 19 11; 26 3
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	3 6; 12 10; 21 13; 30 17
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	7 7; 15 17; 24 4
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	1 6; 8 1; 21 15; 28 9
UW Cygni	19.6	+42 55	10.5—13	3 10.8	6 12; 13 10; 20 8; 27 5
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	13 0
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	6 21; 16 11; 26 2
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 7; 18 12; 27 16
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	4 12; 12 0; 19 12; 27 0
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 4; 8 0; 19 17; 31 9
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	4 0; 14 2; 24 5
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	1 5; 8 14; 23 9; 30 18
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	6 15; 16 8; 26 0
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	6 17; 14 14; 22 11; 30 8
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	29 20
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 10; 13 13; 23 16
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	1 8; 6 12; 16 21; 27 6
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	6 4; 11 15; 22 12; 27 23
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	6 22; 15 5; 23 12; 31 19
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	4 4; 11 17; 19 6; 26 18
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	8 14; 16 20; 25 2

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and May E. Abbott at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1914 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	2 22;	11 1;	19 4;	27 8				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 15;	11 8;	19 2;	26 20				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	6 7;	21 2						
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 1;	12 23;	21 22;	28 21				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8 11;	16 6;	24 2;	31 21				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	8 5;	15 11;	22 18;	30 1				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	4 0;	20 0						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	3 13;	12 3;	20 17;	29 7				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 18;	14 21;	25 23					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	4 3;	15 18;	27 9					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	5 1;	12 17;	20 8;	28 0				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	3 3;	13 7;	23 10					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 20;	14 13;	22 6;	30 0				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	6 0;	11 13;	22 14;	28 3				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 2;	11 15;	19 5;	26 19				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			23 10					
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 9;	14 14;	21 19;	29 0				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	3 4;	11 2;	19 0;	26 22				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 6;	13 10;	23 14					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		17 3						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5		10 18;	18 17;	26 16				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	2 16;	9 8;	22 18;	29 10				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	2 19;	12 2;	21 9;	30 15				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	4 23;	13 17;	22 11;	31 5				
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	7 1;	13 20;	20 15;	27 10				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 11;	12 2;	25 7;	31 21				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8		10 7;	19 22;	29 14				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 22;	10 21;	18 21;	26 20				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 6;	12 23;	19 17;	26 10				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	5 3;	10 22;	22 14;	28 10				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	3 4;	12 13;	21 22;	31 7				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	2 17;	20 0						
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	4 0;	12 5;	20 10;	28 14				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	2 13;	9 14;	23 15;	30 15				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	8 12;	16 17;	24 22					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	2 18;	13 18;	24 17;	30 5				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	5 6;	12 19;	20 8;	27 21				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7 2;	14 12;	21 22;	29 8				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	1 19;	8 14;	22 3;	28 22				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 22;	12 6;	24 22;	31 5				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	3 19;	13 13;	23 7					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6 19;	15 16;	24 12					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	4 17;	10 19;	22 22;	28 23				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	4 18;	11 19;	18 19;	25 19				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		14 20;	31 23					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	3 7;	10 21;	18 11;	26 1				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	2 11;	8 6;	19 19;	31 8				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 16;	10 10;	23 22;	30 16				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6 11;	16 20;	27 4					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	1 8;	13 9;	25 11;	31 12				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	1 0;	7 3;	19 10;	31 17				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 20;	9 19;	21 16;	27 15				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	4 1;	13 3;	22 5;	31 8				

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1914. May
	h m	° ′		d h	d h d h d h d h d h
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	3 15; 10 15; 24 16; 31 17
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6 10; 13 10; 20 10; 27 10
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4 3; 12 2; 20 2; 28 1
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 20; 10 12; 18 5; 25 21
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	6 18; 13 22; 21 2; 28 6
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	5 20; 14 5; 22 14; 31 0
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 2; 10 10; 23 1; 29 9
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	14 17; 31 2
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 19; 10 16; 19 13; 28 10
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	7 11; 14 4; 20 22; 27 15
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	1 12; 8 5; 21 16; 28 9
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	14 22; 29 16
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8 7; 16 3; 24 0; 31 21
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	5 5; 12 2; 18 23; 25 21
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 6; 9 2; 18 20; 28 13
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	1 6; 9 22; 18 13; 27 5
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	2 21; 8 6; 19 0; 29 17
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	6 18; 17 15; 28 12
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	3 18; 10 3; 23 0; 29 10
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	1 7; 11 6; 21 5; 31 5
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 5; 9 15; 20 12; 31 10
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 7; 7 14; 20 4; 26 11
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	3 17; 15 20; 28 0
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	5 6; 10 6; 20 6; 30 5

New Variable Stars.—In *A. N.* 4710 is announced the discovery of the first new variable for this year, 1.1914 Cygni. The attention of Dr. Kritzinger was drawn to this star, B.D. + 34° 4127, (in position for 1900, $20^h\ 38^m\ 27^s$, + 35° 5′.9) because of the discordance introduced into the observations of X Cygni when this star was used for comparison. Dr. Guthnick also observed this star and the combined data seem to indicate that this star is of the Algol type, having the unusually long period of about fifty days. Minima are predicted for April 6 and May 25. Its mean magnitude is a little brighter than the seventh.

In *A. N.* 4711, Professor H. C. Plummer announces the discovery of a new variable star 2.1914 Cygni by Mr. Martin. This star is near the variable XZ Cygni. Its range of variation is from $9^m.0$ to $9^m.5$. The statement is made that the light fluctuates rapidly, but apparently in an irregular or complex way.

The variable 3.1914 Leonis minoris is announced in *A. N.* 4712 by W. Ceraski. It was found by Mme. L. Ceraski in January. Its position is given as approximately $\alpha = 10^h\ 19^m\ 45^s$, $\delta = +\ 29°\ 19'$ (1900.0). It seems to vary from about $9^m.5$ to $10^m.5$, and the period is probably short, perhaps only a few hours.

In *A. N.* 4517 Professor S. Kostinsky calls attention to a faint star near 61 Cygni which is probably variable. It is given the provisional number of 4.1914 Cygni. The star is about 10′ south east of 61 Cygni, is very red, and is of about 11^m to 12^m.

The variable 5.1914 Canum venaticorum is announced in *A.N.* 4716. It was found by Mme. L. Ceraski on examining photographic negatives. This star is very faint and seems to vary from the eleventh magnitude to less than 12.5. Its period may be 8 or 9 months long.

COMET AND ASTEROID NOTES.

Comet 1913 *f* (Delavan).—The comet is brightening as predicted but during the next two or three months will be too nearly behind the sun to be observed. When we are able to observe it next it will be a morning object seen toward the northeast. An observation obtained at Goodsell Observatory on March 19 shows that the comet is following very closely the course indicated by the elements of Einarsson and Nicholson, given in our last number, page 184. The predictions given on page 185 are, therefore, probably very close. In *A. N.* 4717 Mr. R. Goudey of Besancon gives elliptic elements based upon observations on Dec. 18, 31 and Jan. 15.

ELLIPTIC ELEMENTS OF COMET 1913 *f*.

$T = 1914$ Oct. 27.6207 Paris mean time
$\omega = 97^\circ\ 34'\ 39''.4$
$\Omega = 59\ \ 07\ \ 22\ .3$ 1914.0
$i = 68\ \ 12\ \ 43\ .3$
$\log q = 0.044374$
$\log e = 9.998530$

CONSTANTS FOR THE EQUATOR.

$x = r\,[9.781063]\,\sin\,(v + 219^\circ\ 24'\ 26''.8)$
$y = r\,[9.909081]\,\sin\,(v + 201\ \ 28\ \ 21\ .2)$
$z = r\,[9.995000]\,\sin\,(v + 117\ \ 47\ \ 27\ .1)$

EPHEMERIS.

	True α	True δ	$\log r$	$\log \Delta$
	h m s	° ′ ″		
April 2	2 59 42.2	+ 9 40 06	0.49527	0.59172
14	3 09 14.6	+11 59 40	0.47642	0.58808
26	3 20 15 6	+14 22 21	0.45652	0.58114
May 8	3 32 42.8	+16 48 56	0.43549	0.57066

Comet 1892 I (Swift), Definitive Elements.—Dr. E. E. Kühne assistant at the Königsberg Observatory has recently published the results of a definitive determination of the orbit of Swift's comet 1892 I, using all available observations. He obtains for the final elements:

Osculation 1892 March 21.0
$T = 1892$ April 6.6910522, Berlin M.T., $\pm$ 0.0001639
$q = 1.0268476 \pm 0.0000025$
$e = 0.9987820 \pm 0.0000123$
$\omega = 24^\circ\ 31'\ 06''.58 \pm 0''.58$
$\Omega = 240\ \ 54\ \ 23\ .94 \pm 0\ \ .74$ 1892.0
$i = 38\ \ 42\ \ 19\ .54 \pm 0\ \ .10$

These elements correspond to a period of 24484 years, with a probable error of 372 years.

Elliptic Elements of Neujmin's Comet, 1913 *c*.—On September 3, 1913 a faint comet was discovered by Neujmin at Simeis. At the time of its discovery it resembled an asteroid more than it did a comet. It was situated in the constellation Pisces, had a very slow motion, and was about the tenth magnitude. Several parabolic orbits were computed, but they all seemed to be unsatisfactory. In one of the recent numbers of the *Astronomische Nachrichten* I found some observations taken at Copenhagen and at Rome. I have just finished an elliptic orbit which shows that the comet is another of Saturn's family. Perihelion distance 1.528 units; aphelion distance 11.985 units. The elements were computed by the method in Watson's Theoretical Astronomy, and the final results all check to seven place decimals. The elements represent the motion of the comet exactly. The differences between the observed and computed middle place is only $0^s.09$ in R.A. and $0''.08$ in Declination.

ELLIPTIC ELEMENTS OF NEUJMIN'S COMET.

$E = 1914$ March 12.50000 G.M.T.
$M = 11° 40' 10''.72$
$\omega = 346\ 16\ 37\ .30$
$\pi = 334\ 10\ 55\ .32$
$\Omega = 347\ 54\ 18\ .02$
$i = 14\ 49\ 2\ .63$
$\log e = 9.8886549$
$\log a = 0.8297506$
$\log q = 0.1841556$
$\mu = 202''.0136$
$P = 17.5644$ years

CONSTANTS FOR THE EQUATOR 1914.0

$x = r\,[9.9993755] \sin(78° 17' 45''.46 + u)$
$y = r\,[9.8971762] \sin(345\ 54\ 08\ .84 + u)$
$z = r\,[9.7899284] \sin(352\ 13\ 32\ .96 + u)$

F. E. SEAGRAVE.

Boston, March 14, 1914.

Elements and Ephemeris of Asteroid MT.—I am sending you my latest elements, constants, and ephemeris of asteroid MT (Albert) for 1915. These are much better than the ones I sent you over a year ago. The asteroid will be in opposition May 21, 1915 at about one unit (92800000 miles) from the earth. It will be pretty faint, but it will be interesting to see if it can be found by photography.

ELEMENTS OF ASTEROID MT (ALBERT).
Epoch and Osculation 1915 April 30.50 G.M.T.

$M = 317° 51' 22.84$
$\pi = 337\ 29\ 19.28$
$\Omega = 185\ 32\ 36.91$
$i = 10\ 49\ 48.50$
$\log e = 9.732842$
$\mu = 853.''66491$
$\log q = 0.074722$

$x = r\,(9.99993) \sin(275\ 26\ 43.60 + u)$
$y = r\,(9.98928) \sin(185\ 12\ 42.\ \ + u)$
$z = r\,(9.34256) \sin(190\ 3\ 41.10 + u)$

Ephemeris MT (Albert) 1915.

1915	α	δ	log r	log Δ
	h m s	° ′ ″		
April 26	16 11 33	−7 21 48	0.33616	0.09192
30	16 9 18	−6 36 57	0.33084	0.07573
May 4	16 6 33	−5 50 27	0.32542	0.06018
8	16 3 20	−5 2 46	0.31990	0.04552
12	15 59 38	−4 14 43	0.31430	0.03185
16	15 55 34	−3 26 46	0.30856	0.01932
20	15 51 10	−2 39 45	0.30274	0.00808
24	15 46 36	−1 54 35	0.29684	9.99826
28	15 41 50	−1 11 52	0.29082	9.98986
June 1	15 37 4	−0 32 30	0.28470	9.98291
5	15 32 23	+0 2 54	0.27846	9.97740
9	15 27 53	+0 33 38	0.27214	9.97331
13	15 23 41	+0 59 8	0.26572	9.97057

Boston, Feb. 14, 1914.

F. E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Feb.-Mar., 1914.—The feature of this month's report is to be noted in the increase in the number of observations of the neglected variables. Seventy observations of these stars were made, as compared with thirty-seven last month. This indicates clearly that our members are endeavoring to carry out Professor Pickering's suggestion regarding these stars.

Mr. Bancroft again leads with 236 observations of 83 variables, a record that any observer may well be proud of.

Dr. Gray deserves credit for his observations of three short period variables that are not recorded in the report.

Mr. Charles F. Richter, "R" of Los Angeles, Cal., makes his first contribution to the reports this month.

Mr. Lacchini writes that he will spend next month observing at the observatory of Capodimonte, Naples. Mr. Yamasaki, who contributed 91 observations this month will shortly leave for Japan to be absent for several months.

Mr. Edmund Mills of New York, one of our new members, and a skillful draughtsman, has made a number of excellent blue prints, thus assisting in the chart distribution that contributes materially to the progress of the work.

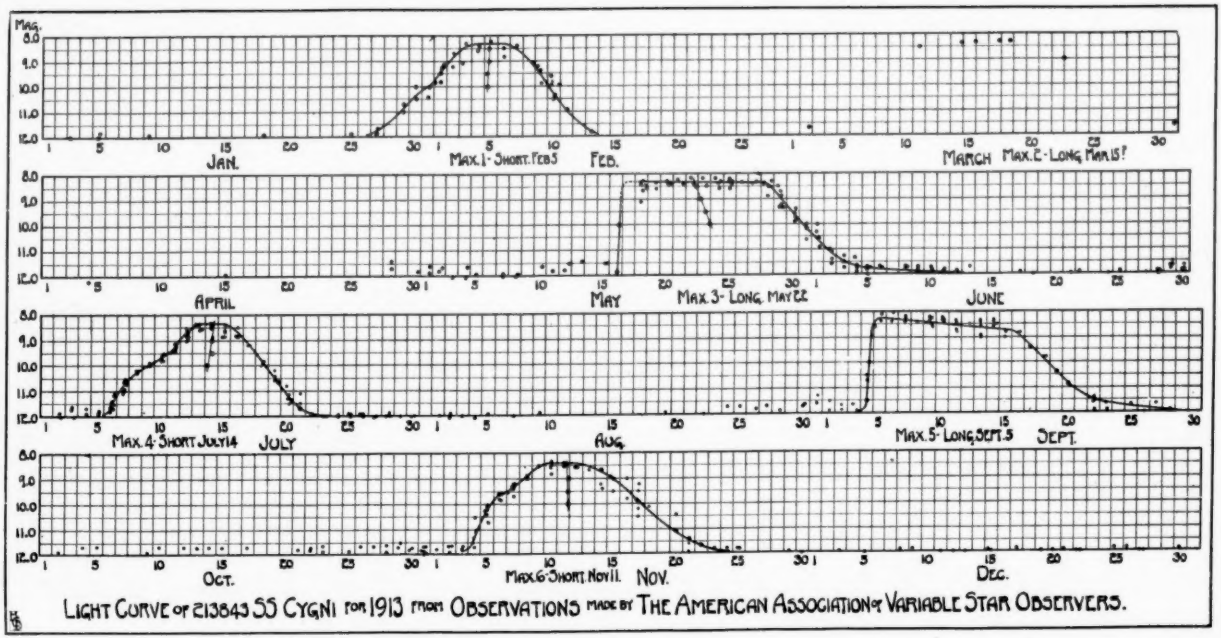
During the month the secretary has distributed over two hundred blue prints, and he will shortly have ready for distribution twenty additional charts of the neglected variables, making a total of 238 blue prints available, a valuable set of charts for any observer.

Discrepancies in the estimates sent in in the case of the following variables call for a note of warning. Observers of these stars should use special care in the matter of identification.

004047 U Cassiopeiae	081112 R Cancri
052404 S Orionis	*084803* S Hydrae
070122a R Geminorum	103769 R Urs. Maj.

The following note is quoted from a recent issue of the *English Mechanic*: "At a recent meeting of the B. A. A. Mr. C. L. Brook, Director of the V. S. S., called attention to the fact that Professor Whitaker of Glasgow has applied the method of Harmonic Analysis to the observed light curves of 213843 SS Cygni, and has found that they are equivalent to a combination or summation of a series of simple uniform wave curves known generally as sine curves." In this connection the light curve of this eccentric variable for the past year, as drawn by Mr. Bancroft from the observations made by the members of the Association, is of special interest. The thanks of the Association are due Mr. Bancroft for this skilfully executed drawing and for his painstaking care in arranging the data. We are indeed fortunate to number among our observers a draughtsman of such ability who is ever willing to promote our best interest.

The writer does not feel qualified to discuss the curve scientifically, but its comparison with the curve of last year published in "POPULAR ASTRONOMY" Vol. 21, pages 237, 309, reveals in the short maxima a decided irregularity. This is especially noticeable in the July and November maxima, where, on the rise, a slight pause appears to be indicated. This feature does not appear in the curve of the V. S. S. of the B. A. A. and is probably fictitious. During the year seventeen members of



LIGHT CURVE OF 213843 55 CYGNI FOR 1913 FROM OBSERVATIONS MADE BY THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS.

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1914.

001620
T Ceti

Mo.	Day	Est	Obs.
2	13	6.5	G

001726
T Androm.

Mo.	Day	Est	Obs.
2	1	11.6	Ba
	15	11.1	Ba
	15	11.8	Br
	19	11.3	Br
3	4	10.2	Y

001755
T Cassiop.

Mo.	Day	Est	Obs.
2	2	8.4	Bu
	21	8.2	Bu
	21	8.8	Ba
	26	8.9	B
	27	9.0	Y
3	1	9.9	G
	3	9.6	S

001838
R Androm.

Mo.	Day	Est	Obs.
2	2	9.3	Bu
	14	7.9	V
	15	8.0	Br
	19	7.7	Br
	21	8.8	Bu
	21	7.5	B

003179
Y Cephei

Mo.	Day	Est	Obs.
2	1	9.7	Ba
	4	9.6	Ba
	9	9.5	Ba
	15	9.6	Ba
	21	9.7	Ba
	25	9.8	Ba
	26	10.0	Ya
	28	10.0	Ya

004047
U Cassiop.

Mo.	Day	Est	Obs.
2	15	11.2	L
	21	11.0	Y
	25	9.8	B
	26	10.5	Ba
	27	10.9	Y
3	3	10.4	S

004132
RW Androm.

Mo.	Day	Est	Obs.
2	12	9.4	Ya
	13	9.4	Ya
	25	9.5	Ya

004533
RR Androm.

Mo.	Day	Est	Obs.
2	1	10.0	Ba
	2	10.0	Bu
	4	9.9	Ba
	11	10.4	Ba
	12	10.7	Ya

RR Androm.

Mo.	Day	Est.	Obs.
2	13	10.9	Ya
	15	10.8	Ba
	21	10.4	Bu
	21	11.4	Bu
	25	11.2	Ya
	26	11.6	Ba

004746
RV Cassiop.

Mo.	Day	Est.	Obs.
2	1	10.8	Ba
	2	11.8	L
	4	10.8	Ba
	11	10.7	Ba
	15	10.4	Ba
	21	10.4	Ba
	26	10.4	Ba

004958
W Cassiop.

Mo.	Day	Est.	Obs.
2	1	10.0	Ba
	4	9.9	Ba
	11	9.9	Ba
	15	10.0	Br
	15	10.1	Ba
	21	9.7	Ba
	24	9.8	J
	25	10.0	Ba
	27	10.0	O

010940
U Androm.

Mo.	Day	Est.	Obs.
2	1	10.3	Ba
	4	10.5	Ba
	11	10.7	Ba
	13	11.1	Ya
	15	10.8	Ba
	21	11.4	Ba
	25	11.6	Ba
	25	11.7	Ya

012502
R Piscium

Mo.	Day	Est.	Obs.
2	21	11.0	Y

011272
S Cassiop.

Mo.	Day	Est.	Obs.
2	1	12.6	Ba
	4	12.4	B
	15	12.9	Ba
	21	13.0	Ba
	25	12.6	B

013338
Y Androm.

Mo.	Day	Est.	Obs.
2	1	10.5	Ba
	2	10.4	Ba
	4	10.7	Ba
	6	10.6	Bu
	11	11.1	Ba
	12	10.8	Bu
	15	11.2	Ba
	21	12.0	Ba
	26	12.6	Ba

014958
X Cassiop.

Mo.	Day	Est	Obs.
2	1	9.9	Ba
	2	10.4	Bu
	4	10.0	Ba
	6	10.0	Bu
	11	10.2	Ba
	12	10.4	Bu
	21	10.3	Ba
	21	10.2	Bu
	24	10.1	Y
	25	10.5	Ba
	26	9.5	B
	26	10.4	Bu
	26	10.7	Ya
	28	10.6	Ya

015254
U Persei

Mo.	Day	Est	Obs.
2	1	8.2	Ya
	1	8.3	Ba
	2	8.4	Bu
	3	8.2	Ya
	4	8.0	Ba
	6	8.2	Bu
	6	8.2	Ya
	10	8.2	Ya
	11	7.9	Ba
	12	8.0	Bu
	21	8.2	Bu
	21	7.9	Ba
	25	8.0	Ya
	25	7.7	Ba
	26	8.2	Bu

021024
R Arietis

Mo.	Day	Est	Obs.
2	1	8.9	Br
	4	8.8	Br
	5	9.2	G
	6	9.8	Bu
	12	8.6	G
	12	8.8	Br
	14	8.8	Br
	15	8.7	Br
	17	8.6	Br
	19	8.6	Br
	25	8.0	O
3	1	7.6	G

021258
T Persei

Mo.	Day	Est	Obs.
2	1	8.5	Ya
	2	8.8	Bu
	10	8.7	Ya
	12	8.8	Bu
	13	8.8	Ya
	14	9.0	Bu
	25	8.7	Ya

021403
o Ceti

Mo.	Day	Est	Obs.
1	29	5.4	L
2	1	4.8	Ya

o Ceti

Mo.	Day	Est.	Obs.
2	2	4.8	Ba
	2	4.8	L
	4	5.0	Ya
	4	4.8	L
	5	5.0	G
	5	4.7	L
	6	4.3	Bu
	6	4.6	Ya
	7	4.6	L
	8	4.6	Ya
	11	4.3	G
	12	4.2	R
	12	4.2	G
	13	3.9	Ya
	13	4.1	G
	15	3.7	L
	17	3.3	L
	20	3.3	L
	21	3.0	R
	22	3.1	R
	23	3.7	R
	25	3.6	O
	25	3.3	G
	26	3.5	R
	26	3.1	Ya
	26	3.2	G
	27	3.2	R
3	1	3.1	G

021558
S Persei

Mo.	Day	Est.	Obs.
2	1	10.5	Ba
	1	10.7	Ya
	4	10.5	Ba
	11	10.6	Ba
	12	10.4	Bu
	13	11.2	Ya
	14	10.4	Bu
	21	10.6	Ba
	25	11.2	G
	25	11.1	Ya
	25	10.8	B
	26	10.7	Ba

022000
R Ceti

Mo.	Day	Est	Obs.
2	21	9.9	Y

022813
U Ceti

Mo.	Day	Est.	Obs.
2	2	10.7	Ba
	2	10.4	Bu
	6	10.6	Bu
	12	10.6	Bu
	12	8.8	G

023133
R Trianguli

Mo.	Day	Est.	Obs.
2	1	7.6	Ba
	2	7.4	Bu
	5	7.7	G
	6	7.4	Bu
	9	7.9	Ba
	15	8.2	Ba
	17	8.6	Br
	21	8.6	Ba
	24	8.4	Y
	25	8.8	Ba
	25	8.8	Le
	25	8.6	B
	26	9.0	O
3	1	8.5	G
	1	9.0	Le

024356
W Persei

Mo.	Day	Est.	Obs.
2	1	10.1	Br
	1	9.1	Ba
	4	9.7	L
	6	9.6	Bu
	9	9.1	Ba
	12	9.8	Bu
	14	9.5	V
	14	9.8	Bu
	15	9.0	Ba
	15	9.7	L
	15	9.0	Hu
	16	9.6	P
	21	9.1	Ba
	25	9.2	Le
	25	9.0	Ba
	25	9.6	G
	26	9.4	Ya
	26	9.7	V
	28	9.4	Ya
3	1	9.2	Le
	3	9.3	P
	4	9.5	O

030514
U Arietis

Mo.	Day	Est.	Obs.
2	4	9.1	Ba
	9	9.0	Ba
	15	8.9	Ba
	21	8.7	Ba
	24	8.8	Y
	25	8.6	Ba

031401
X Ceti

Mo.	Day	Est.	Obs.
2	10	10.0	Ya
	11	9.6	Ya
	13	9.8	Ya
	13	9.7	G
	25	10.6	Ya

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032043
Y Persei

Mo.	Day	Est.	Obs.
2	4	9.4	Ba
	6	10.0	Bu
	9	9.5	Ba
	12	9.8	Bu
	14	9.8	Bu
	15	9.4	Ba
	15	9.0	Hu
	16	10.0	P
	21	9.5	Ba
	23	9.8	G
	25	9.6	Ba
	26	9.7	Ya
	27	9.7	O
	28	9.7	Ya
3	3	9.7	P

032335
R Persei

2	4	8.6	Ba
	4	9.0	Ya
	6	9.0	Ya
	9	8.7	Ba
	13	9.1	Ya
	15	8.7	Ba
	15	8.9	Hu
	21	8.8	Ba
	25	9.8	G
	25	9.7	Ya
	25	9.1	Ba
	27	10.1	Y

033362
U Camelop.

2	1	7.5	Br
	1	7.3	Ba
	9	6.9	Ba
	12	7.4	Br
	14	7.4	Br
	15	7.6	Br
	17	7.6	Br
	18	7.8	Br
	19	7.8	Br
	21	6.9	Ba
	25	6.9	Le
	26	6.7	Ba
	26	7.3	G
3	1	7.0	Le

034625
U Eridani

2	12	11.0	G

035124
T Eridani

2	12	8.4	G

035915
V Eridani

2	1	9.1	Ba
	4	9.1	Ba
	15	9.1	Ba
	21	9.2	Ba

042209
R Tauri

2	21	13.0	Y

042215
W Tauri

2	2	9.2	Bu
	4	9.2	Ba
	6	9.2	Bu
	7	9.9	Gu
	9	9.5	Ba
	11	9.2	G
	12	9.6	Bu
	14	9.4	Bu
	15	10.0	Ba
	21	9.9	B
	21	10.2	Ba
	21	10.1	Y
	23	10.4	G
	25	10.5	Ba
	25	10.5	G
	26	10.3	O
	26	9.8	Bu
	27	10.6	M
	27	10.3	Ya
	28	10.7	Ya

042309
S Tauri

2	21	13 ±	Y

043065
T Camelop.

2	24	9.6	Y
	26	9.3	G

043208
RX Tauri

2	4	9.1	B
	4	9.0	Ba
	9	9.1	Ba
	15	9.0	Ba
	15	8.7	Hu
	16	9.5	P
	21	9.2	B
	21	9.1	Ba
	25	9.2	Ba
	26	9.3	O
3	3	9.2	Hu
	3	9.7	P

043274
X Camelop.

2	24	11.1	Y
	25	11.4	O
	27	11.1	O
3	4	10.5	O

044617
V Tauri

2	15	9.0	Ba
	26	9.3	Ba

045307
R Orionis

2	2	11.2	Ba
	15	10.7	Ba
	21	10.2	Ba
	25	9.7	Ya
	26	10.0	O
	26	9.8	Ba
	27	10.0	Y

045514
R Leporis

2	1	8.1	Ya
	2	9.2	L
	4	8.1	Ya
	4	7.5	Ba
	5	9.3	L
	6	7.8	Bu
	6	7.9	G
	6	7.9	Ya
	10	7.6	Ya
	11	7.9	G
	14	8.0	Bu
	14	8.1	G
	15	7.6	Ba
	15	9.1	L
	20	8.7	L
	25	7.7	Ya
	25	8.1	Le
	25	8.1	G
	26	7.7	B
	26	7.4	Ba
3	1	7.7	G
	1	7.9	Le

050001
W Orionis

2	5	6.0	G
	23	6.5	G
3	1	6.1	G

050022
T Leporis

2	3	9.4	G
	11	9.1	G

050953
R Aurigae

2	2	8.2	Bu
	4	8.1	Ba
	9	8.0	Ba
	12	8.2	Bu
	15	8.1	Ba
	25	8.3	Ba
	26	8.2	Ya
	28	8.3	Ya
3	2	8.1	G
	3	8.2	P

052034
S Aurigæ

2	2	10.4	L
	2	9.5	Ba
	9	9.3	Ba

S Aurigae

2	15	9.4	Ba
	16	10.2	P
	17	10.5	L
	21	9.9	Y
	26	9.4	Ba
	26	9.1	B
3	3	10.2	P

052036
W Aurigæ

2	4	9.8	Ba
	9	9.9	Ba
	14	10.9	V
	15	10.0	Ba
	16	10.6	V
	21	10.5	Ba
	25	10.6	Ba

052404
S Orionis

2	2	12.3	Ba
	21	12.4	Ba
	21	13.1	Y
	26	12.7	Ba

053005a
T Orionis

2	5	10.0	G
	15	10.2	Ba
	25	9.8	Ba
	25	9.9	G

053068
S Camelop

2	26	9.1	G

054629
R Columbae

1	31	10.0	G

054920
U Orionis

2	15	11.2	Hu
	15	11.3	Ba
	21	11.1	Ba
	27	10.2	Y
	27	10.6	O
3	3	10.3	Hu

055353
Z Aurigae

2	21	10.4	Y

060124
S Leporis

2	3	6.6	G
	11	6.5	G
	26	6.5	G

060450
X Aurigae

2	2	9.7	Ba
	15	9.1	Ba
	20	9.1	V

X Aurigae

2	21	8.7	Ba
	26	8.7	Ba
3	3	8.5	P

061647
V Aurigae

2	2	9.0	Ba
	15	9.3	Ba
	24	9.7	Y
	26	9.6	Ba

061702
V Monoc.

2	3	8.4	G
	4	7.9	Ba
	11	7.7	G
	15	7.0	Ba
	17	7.1	V
	21	7.3	Ba
	25	6.6	G
	26	7.1	V
	26	7.0	Ba
3	1	6.7	G

063159
U Lyncis

2	15	13.6	Ba
	21	13.1	Ba
	26	12.9	Ba

063558
S Lyncis

2	15	13.8	Ba
	21	13.6	Ba
	26	13.4	Ba

064030
X Geminorum

2	2	12.8	Ba
	26	10.6	Ba
	27	10.0	Y
	28	10.3	V

064932
NOVA GEMIN. II

1	30	10.9	L
2	3	11.1	Ya
	4	10.8	L
	6	11.0	Bu
	11	11.1	Ya
	11	11.1	G
	15	11.2	L
	17	11.2	V
	21	11.3	Ba
	25	11.2	Ya
	26	10.9	G
	26	10.8	V

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065111
Y Monoc.

Mo.	Day	Est.	Obs.
2	13	9.6	G
	20	10.6	V
	25	9.1	G
3	1	9.6	G
	2	10.6	V

065208
X Monoc.

Mo.	Day	Est.	Obs.
2	2	7.8	L
	3	7.9	G
	4	8.0	Ba
	11	7.9	G
	11	8.0	Ya
	13	8.1	Ya
	14	8.1	G
	15	7.9	L
	21	7.7	Ba
	25	7.5	G
	26	7.7	Ya
	26	7.7	Ba
3	1	7.5	G

065355
R Lyncis

Mo.	Day	Est.	Obs.
2	2	8.0	Bu
	12	7.8	Bu
	14	7.8	Bu

070122a
R Gemin.

Mo.	Day	Est.	Obs.
2	3	9.1	G
	15	11.9	Hu
	24	12.3	B
3	3	11.3	Hu

070310
R Can. Min.

Mo.	Day	Est.	Obs.
2	2	10.0	L
	2	9.4	Ba
	2	10.2	V
	5	9.7	G
	11	9.6	G
	15	10.0	L
	25	9.8	G
	26	10.5	V
	27	10.5	O

071044
L_2 Puppis

Mo.	Day	Est.	Obs.
2	13	4.5	G

071713
V Gemin.

Mo.	Day	Est.	Obs.
2	3	8.5	G
	26	8.4	G
	27	8.2	Y

072708
S Can. Min.

Mo.	Day	Est.	Obs.
2	2	7.9	L
	2	8.0	Bu
	3	7.7	G

S Can. Min.

Mo.	Day	Est.	Obs.
2	4	7.8	B
	5	7.4	L
	5	7.6	Ya
	6	7.5	Ya
	9	7.3	Ba
	11	7.5	Ya
	11	7.5	G
	12	7.7	R
	12	7.6	Bu
	14	7.6	Bu
	15	7.4	L
	21	7.3	B
	21	7.3	Ba
	21	7.6	R
	22	7.8	R
	23	7.5	R
	24	7.8	M
	25	7.7	O
	25	7.6	Ya
	25	7.4	G
	26	7.4	Bu
	26	7.5	R
	26	7.5	Ba
	27	7.5	O
	27	7.8	R
	27	7.9	M
	27	8.0	St
3	1	7.4	St
	3	7.8	S
	4	7.5	St
	4	7.5	O
	5	7.5	St

072811
T Can. Min.

Mo.	Day	Est.	Obs.
2	24	9.5	Y

073508
U Can. Min.

Mo.	Day	Est.	Obs.
2	2	10.4	L
	2	10.4	Bu
	4	10.5	B
	4	10.6	Ba
	11	11.0	G
	15	10.9	L
	21	11.4	Ba
	22	11.1	B
	25	11.5	Ya
	26	11.7	Ba

073723
S Gemin.

Mo.	Day	Est.	Obs.
2	24	11.0	Y

074323
T Gemin.

Mo.	Day	Est.	Obs.
2	24	8.8	Y

074922
U Gemin.

Mo.	Day	Est.	Obs.
2	21	10.6	Ba
	24	11.6	B

081112
R Cancri

Mo.	Day	Est.	Obs.
2	2	10.6	Bu
	3	11.1	L
	4	10.5	Ba
	6	10.4	Bu
	14	10.4	Bu
	15	10.6	L
	21	10.4	Ba
	24	11.0	M
	26	10.2	Bu
	26	10.5	Ba
3	3	11.7	Hu

081617
V Cancri

Mo.	Day	Est.	Obs.
2	2	9.4	Bu
	6	9.6	Bu
	14	9.6	Bu
	26	9.8	Bu

081733
T Lyncis

Mo.	Day	Est.	Obs.
2	26	11.2	G

082405
RT Hydrae

Mo.	Day	Est.	Obs.
2	2	8.1	Ba
	2	8.0	Bu
	4	8.6	L
	12	8.4	Bu
	13	8.3	G
	14	8.4	Bu
	15	8.2	L
	19	8.1	V
	25	7.6	G
	26	8.6	Bu
	28	8.1	V
3	4	7.9	O

083019
U Cancri

Mo.	Day	Est.	Obs.
2	4	9.9	Ba
	21	9.2	Y
	21	9.5	Ba
	26	9.4	Ba

084803
S Hydrae

Mo.	Day	Est.	Obs.
2	13	10.8	G
	21	12.9	Ba
	24	12.0	Ba
	26	10.6	G
3	3	10.9	Hu

085008
T Hydrae

Mo.	Day	Est.	Obs.
3	4	9.7	O

085120
T Cancri

Mo.	Day	Est.	Obs.
2	2	8.6	Ba
	2	8.0	Bu
	3	9.4	L
	6	9.4	L
	12	8.2	Bu
	15	9.2	L
	19	8.7	V
	21	8.2	Ba
	26	9.4	V
	26	7.8	Bu
	27	9.1	O
3	3	8.9	Hu

090425
W Cancri

Mo.	Day	Est.	Obs.
2	21	12.8	Ba
	21	13.5	Y

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
2	2	8.0	Bu
	3	7.2	G
	12	7.8	G
	12	7.8	Bu
	14	7.8	Bu
	15	8.1	Br
	23	8.1	G
	24	8.8	M
	26	8.2	Bu
	26	8.9	O
	28	8.9	Ya
3	1	7.7	St
	3	8.6	Hu
	3	9.0	P
	3	8.8	S
	4	8.8	O

094211
R Leonis

Mo.	Day	Est.	Obs.
1	30	5.9	L
2	2	6.2	Bu
	3	6.1	L
	3	6.1	Ya
	3	5.7	G
	4	5.6	Ba
	5	6.1	L
	6	6.0	L
	6	6.1	Ya
	11	6.0	Ya
	12	6.0	Bu
	12	5.6	G
	13	6.2	Ya
	14	5.8	Bu
	14	5.8	G
	15	6.0	Br
	15	6.2	L
	19	6.7	V
	19	6.7	M
	21	5.8	Ba
	23	6.0	G
	24	6.8	M

R Leonis

Mo.	Day	Est.	Obs.
2	25	6.4	Le
	25	6.1	O
	25	6.1	G
	26	6.2	Ya
	26	6.5	B
	26	5.6	Bu
	26	6.4	S
	27	6.8	M
	27	6.0	St
	28	6.7	V
3	1	6.0	St
	1	6.5	Le
	2	5.9	G
	4	6.2	O
	4	6.4	St
	5	6.4	St

094622
Y Hydrae

Mo.	Day	Est.	Obs.
2	13	6.5	G
	26	6.7	Ba

103012
U Hydrae

Mo.	Day	Est.	Obs.
2	5	4.6	L
	26	5.9	G
	26	4.8	Bu

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
2	15	13.1	Ba
	21	12.7	Ba
	24	12.9	B
	25	12.5	Ba

104620
V Hydrae

Mo.	Day	Est.	Obs.
2	23	8.2	G
	26	7.0	Ba

105517
R Crateris

Mo.	Day	Est.	Obs.
2	23	8.0	G

120012
SU Virginis

Mo.	Day	Est.	Obs.
2	22	12.1	Ba

122001
SS Virginis

Mo.	Day	Est.	Obs.
2	22	6.6	Ba

122532
T Can. Ven.

Mo.	Day	Est.	Obs.
2	26	9.3	Bu

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
2	15	12.4	Ba
	21	12.0	Ba
	21	12.1	B
	25	11.8	Ba
	27	10.9	Ya
3	1	10.8	G

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123307
R Virginis

Mo.	Day	Est.	Obs.
2	22	8.2	Ba
3	3	9.3	S

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
2	1	8.7	Br
	3	8.5	L
	4	8.2	Ba
	5	8.5	G
	6	8.4	L
	7	7.9	B
	9	8.6	M
	9	8.0	Ba
	12	8.4	G
	12	8.6	Br
	14	8.5	G
	14	8.5	Br
	15	8.5	Br
	15	8.1	Ba
	17	8.3	Br
	17	8.5	L
	18	8.4	Br
	19	8.4	Br
	19	8.6	M
	21	7.8	B
	21	7.9	Ba
	23	8.0	G
	24	8.4	M
	25	8.0	Ba
	25	8.2	O
	25	8.6	Le
	26	8.4	Bu
	26	8.8	S
	27	8.3	M
	27	8.2	Ya
3	1	8.1	Le
	1	7.8	G
	4	8.2	O

124204
RU Virginis

Mo.	Day	Est.	Obs.
2	22	12.6	Ba

124606
U Virginis

Mo.	Day	Est.	Obs.
2	15	9.3	Br
3	3	9.5	S

132422
R Hydrae

Mo.	Day	Est.	Obs.
2	3	6.0	L
	5	6.2	L
	6	6.6	G

132706
S Virginis

Mo.	Day	Est.	Obs.
2	3	8.0	L
	5	8.2	L

133273
T Urs. Min.

Mo.	Day	Est.	Obs.
2	2	11.0	Ba

133674
V Urs. Min.

Mo.	Day	Est.	Obs.
2	25	7.8	G

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
2	4	8.4	L
	6	8.5	L
	9	8.4	Ba
	9	8.3	M
	17	8.3	L
	25	8.1	Ba
	26	8.2	Bu
3	3	8.0	S

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
2	2	8.4	Bu
	9	8.7	Ba
	12	8.2	Bu
	14	8.4	Bu
	15	8.7	Ba
	21	8.7	Ba
	26	8.7	Ba
	26	8.8	B
3	3	8.8	S

141954
S Boötis

Mo.	Day	Est.	Obs.
2	3	9.9	L
	5	9.7	L
	9	9.9	Ba
	15	9.5	Br
	17	9.3	L
	22	9.4	Ba
	26	9.2	Ba
3	3	9.0	S

142539
V Boötis

Mo.	Day	Est.	Obs.
2	3	10.4	L
	9	10.4	M
	17	9.9	L
	25	10.5	Le
	25	10.0	G
3	1	10.5	Le
	1	9.7	G
	3	9.9	S

142584
R Camelop.

Mo.	Day	Est.	Obs.
2	1	8.9	Ya
	2	8.8	Ba
	3	8.8	L
	3	8.9	Ya
	4	8.8	B
	5	8.9	L
	5	8.9	Ya
	11	9.0	Ya
	15	8.8	L

R Camelop

Mo.	Day	Est.	Obs.
2	24	8.4	B
	25	8.7	O
	25	8.4	Ba
	25	8.3	Le
3	1	8.4	Le
	4	8.0	O

143227
R Boötis

Mo.	Day	Est.	Obs.
2	3	7.3	L
	5	7.2	L
	6	7.3	G
	6	7.2	L
	9	7.3	M
	17	7.9	L

150605
Y Librae

Mo.	Day	Est.	Obs.
2	4	12.0	L

151520
S Librae

Mo.	Day	Est.	Obs.
2	4	11.0	L

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
2	3	8.0	L
	5	8.0	L

151822
RS Librae

Mo.	Day	Est.	Obs.
2	4	9.9	L
	6	10.1	L

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
2	2	12.3	Ba
	4	11.4	B
	5	12.1	L
	17	12.4	L
	25	12.3	Ba
	26	12.0	B
3	2	11.5	G

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
2	3	6.0	L
	5	6.0	L
	6	5.5	G
	22	5.8	Ba

155847
X Herculis

Mo.	Day	Est.	Obs.
2	4	6.3	L

162119
U Herculis

Mo.	Day	Est.	Obs.
2	6	9.7	G

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
2	2	10.1	Ba
	4	9.8	B
	9	9.7	Ba
	25	10.3	Ba
	26	10.2	B

163266
R Draconis

Mo.	Day	Est.	Obs.
2	9	10.8	Ba
	15	10.6	Ba
	22	9.7	Ba
	24	9.4	Y
	26	9.1	Ba
3	3	9.1	S

165030
RR Scorpii

Mo.	Day	Est.	Obs.
2	6	10.5	G

175458
T Draconis

Mo.	Day	Est.	Obs.
2	24	10.9	Y

184205
R Scuti

Mo.	Day	Est.	Obs.
2	3	5.5	L
	5	5.4	L
	6	5.4	L

191350
TZ Cygni

Mo.	Day	Est.	Obs.
1	29	10.9	L

193449
R Cygni

Mo.	Day	Est.	Obs.
2	1	9.5	Ba
	3	9.5	L
	5	9.1	L

193732
TT Cygni

Mo.	Day	Est.	Obs.
2	4	8.0	L

194048
RT Cygni

Mo.	Day	Est.	Obs.
2	1	9.5	Br
	1	9.2	Ba
	3	9.2	L
	5	9.1	L

194348
TU Cygni

Mo.	Day	Est.	Obs.
2	1	9.4	Ba
	3	9.1	L
	5	9.1	L

194632
χ Cygni

Mo.	Day	Est.	Obs.
2	3	8.7	L
	6	8.7	L

200647
SV Cygni

Mo.	Day	Est.	Obs.
2	4	9.5	L

200938
RS Cygni

Mo.	Day	Est.	Obs.
2	4	7.7	L
	6	7.6	L

201647
U Cygni

Mo.	Day	Est.	Obs.
2	4	11.1	L

202539
RW Cygni

Mo.	Day	Est.	Obs.
2	1	8.5	Ya
	6	8.8	G

202938
SZ Cygni

Mo.	Day	Est.	Obs.
2	1	10.2	Br
	1	9.5	Bu
	1	9.8	Ya
	11	9.2	Ya
	15	9.5	Br

202954
ST Cygni

Mo.	Day	Est.	Obs.
2	1	11.5	Ba

203046
TV Cygni

Mo.	Day	Est.	Obs.
2	1	10.0	Ya
	11	9.9	Ya

210868
T Cephei

Mo.	Day	Est.	Obs.
2	1	8.8	Ya
	1	8.1	Ba
	2	8.5	Bu
	3	8.8	L
	4	8.6	Ya
	5	8.8	L
	6	8.6	Ya
	11	8.4	Ya
	11	8.1	Ba
	11	8.6	Ya
	12	8.7	Bu
	13	9.2	G
	14	8.8	V
	14	8.8	Bu
	15	10.1	Br
	17	9.2	L
	21	9.0	Ba
	24	8.9	V
	25	9.4	Ya
	26	9.3	Ba
3	1	9.0	St
	4	9.0	St
	4	9.4	S

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1914.

213244 W Cygni

Mo.	Day	Est.	Obs.
2	2	6.3	L
	3	5.9	L
	5	6.0	L
	15	5.8	L
	16	6.0	L

213678 S Cephei

Mo.	Day	Est.	Obs.
2	1	10.0	Ba
	21	11.5	Ba
	26	11.6	Ba

213843 SS Cygni

Mo.	Day	Est.	Obs.
1	29	9.6	L
2	1	11.0	Ya
	1	11.6	Ba
	5	12.0	L
	15	11.8	L

213937 RV Cygni

Mo.	Day	Est.	Obs.
2	6	6.3	L

230110 R Pegasi

Mo.	Day	Est.	Obs.
2	2	9.9	Ya

230759 V Cassiop.

Mo.	Day	Est.	Obs.
2	1	10.2	Ba
	9	10.8	Ba
	21	11.3	Ba
	26	11.7	Ba

233335 ST Androm.

Mo.	Day	Est.	Obs.
2	1	10.8	Ba
	2	10.4	Bu

ST Androm.

Mo.	Day	Est.	Obs.
	3	10.8	Ya
	13	11.0	Ya
	15	11.2	Ba
	25	11.0	Ya

235525 R Cassiop.

Mo.	Day	Est.	Obs.
2	25	10.9	B

235525 Z Pegasi

Mo.	Day	Est.	Obs.
2	1	9.5	Ba
	12	10.4	V

235559 658 Bir Cassiop.

Mo.	Day	Est.	Obs.
2	5	7.2	G
	6	7.2	G
	11	7.3	G
	23	7.3	G
3	1	7.3	G

235939 SV Androm.

Mo.	Day	Est.	Obs.
2	1	12.6	Ba
	21	12.6	B

No. of observations 871; No. of stars observed 145; No. of observers 19.

our Association made 509 observations of this variable. The V. S. S. of the B. A. A. contributed 677 observations. These figures indicate how well this wonderful star has been observed, and is good evidence of the valuable work that is being done to advance our knowledge of astrophysics.

The Secretary is in receipt of a communication from Mr. J. Van der Bilt of the Observatory of Utrecht, correcting a misstatement in the December-January report in "POPULAR ASTRONOMY" at page 120 anent the variable 074922 U Geminorum. The period of the variable as stated ranges from 71 to 126 days. This statement, taken from Miss Clerke's "Problems in Astrophysics", is erroneous. Mr. Van der Bilt has made a careful study of all the observations available for this variable, covering a period of fifty years, and has published a valuable discussion of these records. The period of this variable, it appears, varies between sixty and one hundred and fifty-two days. Mr. Van der Bilt thus alludes to the necessity of closely following this variable: "The character of variability of such stars as U Geminorum renders a look at them every clear night absolutely necessary". This of course applies to 213843 SS Cygni, and 060547 SS Aurigae.

The *English Mechanic* cites the following calculated dates of maxima:

Feb. 13	021024 R Arietis	Feb. 26	030514 U Arietis
" 19	123307 R Virginis	" 28	142584 R Camelop.

Inasmuch as *021403 o* Ceti is now brighter than most of our observers have ever seen it, a brief mention of its recorded maxima may be of interest. In only thirty out of 144 recorded maxima down to 1905, has Mira been observed as a second magnitude star. Its brightest maximum is 2.2 and so observed by Argelander October 10, 1839, and by Flanery October 3, 1898. At this writing the variable is close to 3.0 magnitude with a calculated date of maximum March 17. It would appear, therefore, that this maximum would be an unusually bright one, and most interesting to observe.

The following observers contribute to this report: Messrs. Bancroft, Bouton, Bruseth, Burbeck, Gray, Guthrie, Hunter, Jacobs, Lacchini, Leonard, McAteer, Olcott, Putnam, Richter, Stepka, Vrooman, Yamasaki, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT.
Corresponding Secretary.

Norwich, Conn., March 10, 1914.

Observations of the Zodiacal Light.—The observations of the Zodiacal Light published in "POPULAR ASTRONOMY" for December 1913 are interesting because they show that there are some observers who have the patience to follow this curious phenomenon. But these records lack the elements which would make them of permanent value. In the first place, there are very few estimates of the cone or band of light, and these estimates are not definite enough. Secondly, remarks on the brightness which state, in a general way, that the light is fainter than on some previous occasions, or that it is "one half as bright as the Milky Way," give no explicit information.

What is there to hinder the observer from making an accurate chart of his observations by drawing contour lines on a carefully prepared map of the region, and stating the magnitude of the portion of the light represented by each contour line by comparing it with some part of the Milky Way which he specifically notes and records? Directions for making such observations are given in a clear, concise article, called "Suggestions to Observers of Zodiacal Light," written by Professor Arthur Searle of the Harvard College Observatory, as an appendix to Miss Mary E. Byrd's "Laboratory Manual of Astronomy" which was published in 1899 by Ginn and Company, Boston, Mass. If all observers of Zodiacal Light would read this article, they would see the futility of carrying on such observations as are commonly made, and would find a way of turning their efforts to greater usefulness clearly mapped out for them.

If two or more people observe the light independently at the same time and place, so that all exterior conditions are the same, by comparing their results, they will be able to determine what peculiarities each has; and after a long series of observations, can eliminate personal equation and conclude whether the light varies in intensity from time to time, and whether it actually flares up or has "pulsations," as Jones termed it. Such observations are very desirable, for it is evident that it cannot be determined from one person's observations, whether what appears to be variation in magnitude is actual or is due to eye fatigue.

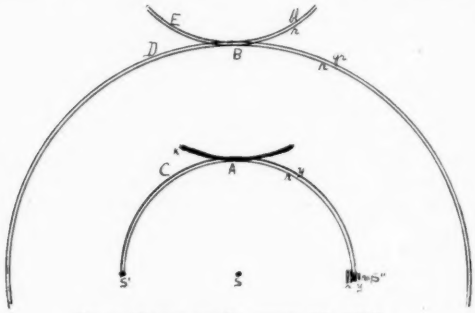
During September, 1912 I began to observe Zodiacal Light at Nantucket, Mass., following Professor Searle's instructions closely. With the coöperation of Mrs. E. S. Morris of Nantucket, many observations were made simultaneously, but, of course, we did not compare impressions or results while working. We continued our observations of the morning light during the autumn of 1913, but as my sojourn on Nantucket has ceased in December of each year, Mrs. Morris is the only observer there to record the evening Zodiacal light. I hope to resume these observations next fall, and not wishing to be influenced in any way, I have refrained from making any comparison of Mrs. Morris's and my records, except in a very few cases, where a hasty glance has proved to me that the personal element is large, and that the coöperation I have described is necessary.

MARGARET HARWOOD.
Fellow of the Nantucket Maria Mitchell Association.

COMMUNICATIONS.

Solar Halos of December 28, 1913.—On December 28, 1913 at Ballston Lake, Saratoga County, New York, I saw solar halos accompanied by tangent arcs, half a parhelic circle, three parhelia, an anthelion and a paranthelion. The figure below is a copy of a pencil sketch made when the phenomenon was at its best.

At $1^h\ 50^m$ I noticed a pair of mock suns, one to the right, one to the left of the sun. The sky was whitened by thin clouds. Immediately after noticing the mock suns I observed two arcs around the sun and an inverted arc tangent to each.



SOLAR HALOS OF DECEMBER 28, 1913.

S = true sun. S′ and S″ = parhelia; at times these were true "mock-suns"; at times, of the form and color arrangement indicated at S″ which was always brighter than S′. C = a faint semi-circle; sometimes this was white. At times I could trace red and yellow as indicated by *r* and *y*. A = a very bright spot, sometimes colored. The horns from a were at one time quite straight and white and Ak = 1/3 AB. D = a little more than a semi-circle. Colors could be seen along the upper part, red to green as indicated. E = brightest arc, just a quadrant. This was very intensely colored, the blue being brilliant.

The angular distance from S to S″ was found roughly by cross-staff principle to be 22°.5. S′ and S″ were on C. D had a radius twice C.

The effects varied from moment to moment. About $2^h\ 30^m$ I saw a third "mock-sun" beyond S″. At this time D was very faint and did not extend through nearly the half circle. This third "mock-sun" was as far from the sun as the radius of D and horizontally to the right.

At $2^h\ 40^m$ a faint "mock-sun" directly opposite the true sun could be seen. From the sun to this, through the west, appeared a horizontal bright white streak with one other bright spot along it about 135° from the true sun. This was not very distinct and was of the form indicated for S″ in the figure but not colored. The pointed end was towards the true sun.

As the sky cleared of clouds, everything faded, arc E remaining after the others.

At $3^h\ 10^m$ both S′ and S″ could be seen but no arcs.

At $3^h\ 40^m$ nothing unusual about the sky. Shortly before sunset there was a bright white appearance above the sun, broader at the sun and tapering upwards.

The sun set clear and there was nothing unusual to be seen. In the evening the sky was clear, details of the Milky Way being well seen.

Reliable witnesses within two miles of the place where I observed had seen at least arc, C, D and E in the morning continuously between $7^h\ 30^m$ and 8^h, at $9^h\ 10^m$ and at 12^h noon. So there is good reason to believe that the phenomenon had persisted nearly all day.

M. M. HOPKINS.

Smith College Observatory,
Northampton, Mass.

Duration of Visibility of a Sunspot.—In the article in POPULAR ASTRONOMY for March, 1913 by Father S. J. Ricard, entitled "Latest Advances in Weather Forecasting", there occurs a serious error which should not be allowed to pass without correction.

On page 134 he definitely states,—"Roughly speaking, a spot takes twelve and one half days to go from limb to limb in front and a little over fourteen days from limb to limb in back (Synodic period)." Further down the page he amplifies this statement further, and makes it more emphatic.

This statement is entirely wrong; a very simple geometrical construction will show that a spot takes half its synodic period to pass from limb to limb, whether on the back or in front of the sun. This has always been known to observers of sun-spots, is so stated in textbooks, and according to Young's General Astronomy, the fact that a sunspot is in view for just as long a time as it is invisible was used by Galileo to prove that they must be on the sun, not bodies revolving near the sun.

ROBERT E. Doyle.

Salinas, California, March 10, 1914.

Brightness of Mercury.—I wish to report that I observed the planet Mercury on 1914 February 17 at 6 P.M., It shone as a star of the first magnitude and was in an excellent position for telescopic observation. At the time of this observation a fresh snow was on the ground and the atmosphere unusually clear. This is the second time in my life that I have had the pleasure of observing Mercury when a fresh snow had fallen near the time of greatest eastern elongation, and on both of these occasions the planet was easily visible to the naked eye, shining as first magnitude.

DR. WILL CASSELL.

Wytheville, Va. 1914, Feb. 18.

The Partial Eclipse of the Moon, March 11, 1914.—The evening of March 11, 1914 was an ideal one here for observing the eclipse of the moon.

It had been cloudy all day, but in the evening it cleared up, and when the eclipse began the sky was cloudless.

Early in the evening, I observed the occultation of τ Leonis, 83 Leonis being already occulted. Although I watched very closely for the reappearance of the two stars at the edge of the moon, I did not see them until they were several seconds away from it. A few minutes before the shadow appeared, the northeast portion of the moon was darkened very much by the penumbra.

When the shadow had advanced as far as the eastern edge of the Mare Serenetatis, I observed the eclipsed portion with the 6″ refractor, power 64, and could see

some of the larger markings, such as Grimaldi, the dark area in Riccioli, the Sinus Iridum, Aristarchus, Copernicus, Plato, and Pico.

At the middle of the eclipse, that portion of the moon covered by the shadow had a reddish or copper color, and with a pair of eight power field-glasses, the maria were plainly visible. The weather being so favorable, and beginning as it did, early in the evening, the eclipse was viewed by many people in this vicinity.

J. J. SCHAFER.

Port Byron, Ill.
March 20, 1914.

GENERAL NOTES.

Professor A. A. Iwanow has been appointed director of the University Observatory at St. Petersburg.

Dr. H. F. Baker, F. R. S., fellow of St. John's College and Cayley lecturer in mathematics, has been elected Lowndean professor of astronomy and geometry in the University of Cambridge in succession to the late Sir Robert Ball.

Miss Annie J. Cannon, of the staff of Harvard College Observatory has been elected to honorary membership in the Royal Astronomical Society (England).

Dr. Edward Singleton Holden, astronomer and Librarian of the United States Naval Academy, formerly director of the Lick Observatory, died on March 15, aged sixty-eight years.

Dr. Arthur S. King, of the Mount Wilson Solar Observatory, gave an address before the astronomical section of the Southern California Academy of Science on the evening of February 23, 1914. His subject was "Applications of Astrophysical Research to the Science of Astronomy." An audience of about one hundred people listened to the address.

Dr. Frederick Slocum, Assistant Professor of Astronomy in the University of Chicago, who since 1909 has been engaged in astronomical research at the Yerkes Observatory, was recently elected Professor of Astronomy in Wesleyan University, Middletown, Conn. In addition to his duties as Professor of Astronomy, Dr. Slocum is to be the director of the new observatory which is to be built during the coming year. This observatory is to be erected from a bequest of $60,000 by Joseph Van Vleck, as a memorial to his brother, Professor J. M. Van Vleck, for many years Professor of astronomy at Wesleyan.

Dr. Slocum is at present examining plans for the new observatory, but will continue his work at Yerkes until July 1. He will assume his active duties at Wesleyan at the opening of the university next fall.

"The Nebular Hypothesis" was the subject of an illustrated lecture given on March 2 by Professor Forest Ray Moulton of the department of astronomy and astrophysics in the University of Chicago, at the Berwyn center of the University Lecture Association, Chicago. On March 16 Professor Moulton speaks at the same place on the subject of "The Sidereal Universe" (*Science*, March 6, 1914.)

Dr. E. A. Fath has resigned his position as director of the Smith Observatory of Beloit College to accept the presidency of Redfield College, Redfield, South Dakota. He has already entered upon his duties at Redfield.

Miss Waterman and Miss Glancy, formerly of the Lick Observatory, sailed the latter part of last summer for Cordoba to begin a period of five years' work with Professor Perrine. Miss Waterman, however, did not carry out the original plan but was recently married in Des Moines, Iowa.

Sir Isaac Newton's House, No. 35 St. Martin's Street, Leicester Square, London, is about to be pulled down, as it is in so ruinous a condition that any attempt to preserve it would be hopeless. This house is not only historic on account of the great philosopher's residence here from 1720 to 1725, but also as the home subsequently of Dr. Burney, the composer, and his daughter Fanny, who wrote her first novel, "Evelina" here. (*Scientific American*, March 21, 1914.)

Lightning at Lick Observatory.—Thunder and lightning are extremely rare phenomena at Lick Observatory. Only once during the year 1910-11, which the editor was privileged to spend upon Mount Hamilton, was there the semblance of a lightning flash and the report following the flash could hardly be called thunder.

On February 18 last, a very severe electrical storm occurred on the mountain, concerning which Professor Aitken writes, in a private letter: "We had more lightning and thunder in an hour that night than in the preceding nineteen years of my residence on the mountain. At least one bolt struck the 36-inch dome and burnt out the outer coil of the dome-motor and set fire to some waste in the basement. Dr. Campbell and several of the men were at hand before the fire got fairly started, so it did no damage. The telescope was not injured. The telephone fuses in the secretary's office were burnt out and many lights suffered; also practically every light-meter on the mountain. I don't expect to live long enough to see another such display here."

Catalogue de la Collection de Météorites de l'Observatoire du Vatican.—Recently a most interesting and valuable work on meteorites has been issued from the Specola Astronomica Vaticana entitled "Catalogue de la Collection de Météorites de l'Observatoire du Vatican" written by M. De Mauroy.

The work contains five chapters, in the first of which the history and theories of the origin of meteorites are reviewed in an interesting manner and at considerable length. Next comes a table containing the names of the principal works formerly published on this subject, which will prove helpful to anyone desiring to become acquainted with its literature. This bibliographical index is due to M. Stanislas Meunier.

The chapters following deal with the circumstances of the falls, the composition of the meteorites themselves, their classification and finally, a detailed explanation of the excellent series of five plates at the end of the memoir, which give 61 illustrations of the 136 different fragments or complete meteorites of the Vatican collection. Besides there are five tables giving the synopsis of the classification of the Vienna, Paris and Vatican collections.

Returning to the first chapter, the history of ancient falls and the opinions then held is given at length. But when we come to the theories of the origin of meteorites only two are given as worthy of belief, namely that they had a common origin with

the asteroids and secondly that they are the remains of a small former satellite of the earth, which was destroyed in some way. Further, no probable differences of origin between iron and stony meteorites are pointed out, though Professor Wm. H. Pickering has shown that it is highly probable that the former are connected most closely with meteor streams and comets. Again few will entirely agree with the conclusion that..."meteors, of which the material is unknown, but appears to be in the state of an extremely tenuous gas, or in a state of dissociation, etc." However, the general differences between meteors and meteorites are clearly and correctly stated.

Passing to the second chapter, detailed descriptions of the phenomena accompanying falls of meteorites are given and also the opinion is hazarded that the ordinary mechanical theory of heat is not directly applicable to a meteorite on account of the suddenness and violence of the shock it undergoes while rushing at immense speed through the atmosphere. The alternative explanation advanced is certainly ingenious, but its merits could only be passed upon by specialists in this particular subject. Attention is particularly called to the fact that certain localities on the earth are much favored by falls while none have ever been observed in others.

The remaining chapters, dealing with the composition, classification and description of these bodies, will prove of the greatest value to anyone studying meteorites from the standpoint of their structures. The plates leave nothing to be desired and, along with the excellent descriptions of the separate pieces, give an opportunity for close study of each one mentioned which will be appreciated by students unable to study the originals. Finally it may be pointed out that the Vatican is probably the only observatory in the world actually containing such an extensive collection of meteorites. On the whole this work will be received with the greatest appreciation by all interested in this branch of astronomy.

CHARLES P. OLIVIER.

Agnes Scott College,
Decatur, Ga.

The Discovery and Study of Variable Stars.—The report of the Committee to visit the Astronomical Observatory of Harvard College is devoted especially to a resumè of the enormous amount of work which has been done at Harvard in connection with the study of the variable stars. We quote the following paragraphs, which will be interesting to many of our readers:

"The application of the photographic method to astronomical research has nowhere proved more fertile in results than in the discovery and observation of variable stars. There have been three different methods devised and very successfully used at Cambridge. First, it was discovered that variable stars of long period have a bright line spectrum when near their maximum brightness. The spectrum due to hydrogen shows its characteristic lines without reversal. This law was utilized by the late Mrs. Fleming in the discovery of new variables. By examining spectrum plates taken with the objective prism, stars with bright hydrogen lines were looked for and then investigated for variability. In this way, 274 long period variables were discovered.

"The second method used for the detection of variables was to give the photographic plate a slight shift at regular intervals during a long exposure. A series of images is thus obtained of all the stars bright enough to make an impression, and these images should, other things being equal, be similar. If, however, the star varies in brightness during the time it is under observation, the images will vary in

intensity. This method has proved an efficient way of detecting variables of short period. A large number of plates have been taken in this manner which have not yet been studied.

"The third, and most successful method of discovering variability in the stars, which has been developed by Professor Pickering, is to superpose a positive and a negative chart plate of a region of the sky. In the negative, the stars are black points on a transparent background; by placing together a positive and the negative from which it was made, when properly superposed the two produce uniform blackness. If, however, a negative is taken that was made at some other time, the uniformity will be lost in the case of those stars which have changed their brightness in the interval, A variable will show itself as a white circle without a black centre or a black speck without a white circle. In fact, any lack of similarity of the circles and images from one another is an evidence of change. By this device Miss Leavitt has discovered more than two thousand variables, nearly a thousand in each Magellanic cloud. Only twenty-five of these have been carefully studied, but from them the significant law has been discovered that there is an interesting relation between the length of time the star requires to go through its changes and its brightness, that the logarithm of the period is proportional to the magnitude of the star at maximum or minimum.

"As an evidence of the accuracy of these investigations it need only be mentioned that Professor Baily has determined the light curve of about 250 of the variables in globular clusters, and in spite of the great difficulties involved has determined the periods with an uncertainty of only two or three tenths of a second. Another striking fact brought out is that these variables when on the upward grade sometimes increase their light 100 per cent in ten minutes,—a rise in brightness only to be compared with that of the so-called Novae.

"A photographic map of the whole sky, consisting of 55 glass plates and showing a million and a half stars, has been issued by the Observatory and 50 copies have been sold at cost.

"A search for variables has been made on these plates and the investigation is now two-thirds completed: when finished, the whole sky will have been examined on a uniform system. This will furnish important information in regard to the number and distribution of variables. And not only that, but by a comparison of the results with the number of known variables on the plates not found in this investigation, a probable estimate may be made of the number of variables yet to be discovered.

"One of the most important discoveries in variable star research was made by Professor Solon I. Bailey: that many peculiar variables of short period exist in and around the globular star clusters. The form of their light curve shows them to constitute a class by themselves. The number so far discovered is 514. The total number of variable stars of all kinds is 4508, of which 3346, or about three-fourths, were found at the Harvard Observatory."

Mountain Transportation.—Building a great observatory on the top of a high mountain requires the solution of problems of transportation quite different from those upon a plain. The following from Professor Hale's report for 1913, shows how the problem has been solved at Mt. Wilson.

"The experience of the Pasadena and Mount Wilson Toll Road Company during the winter of 1912-13 had shown that motor trucks could be operated successfully over the 9-mile road leading to the summit of the mountain, and in March of this

year a 1-ton truck was purchased by the Observatory. This was followed in April by the purchase of a similar truck of three tons capacity. Both trucks are provided with excess water capacity to guard against overheating the engines during the very severe service on the mountain grades. The exceptionally powerful engine and frame of the larger truck are supplemented with a special gear-train to permit the transportation of loads as great as five tons in case of necessity, at a low rate of speed. Both trucks have been in regular service since their purchase, and have made daily round trips from Pasadena to the mountain, with but very few exceptions. The rapid transportation of material in this way has made it possible to complete the large pier and the foundations for the 100-inch telescope mounting and building within a single season. Moreover, it is greatly to the advantage of the members of the staff, who formerly walked or rode up the old trail, to be able to leave Pasadena any morning at $9^h\ 30^m$ and reach the summit of Mount Wilson before noon.

The substitution of heavy motor trucks running daily for lighter mule teams going up on alternate days involves increased wear of the mountain road, which now demands more constant care. Additional daily labor will make it possible to continue the use of the road, almost without interruption, through the winter season, when it was formerly closed for several months. It will also reduce materially the heavy spring task of removing from the road the slides of earth brought down by winter rains."

The Lunar Crater Einmart.—The following statement has been received from Professor W. H. Pickering, in charge of the Mandeville Station of this Observatory:—

Attention was called to the lunar crater, Einmart, in *A. N.* 4704. It is there stated that its interior was very brilliant in January, 1913, but since March had been very much darker. This darkness persisted throughout the remainder of the year, and through January of this year. In February, however, it again brightened up, being about as bright as it was in February, 1913, though by no means as brilliant as in January of that year. As it is a large crater, 25 miles in diameter, the brightness of its interior may be easily observed, even with a small telescope and under unfavorable atmospheric conditions. This past month it has been clearly brighter than any area of similar size between it and the limb. This had not been the case since the previous March. In the preceding January it was the brightest area of that size, visible at that time upon the moon. All observations should be made immediately following the first quarter.

The interior is full of fine brilliant detail, constantly varying not only from night to night, but also from month to month. This observation is, however, probably too difficult for any northern telescope, since it requires not merely one, but a succession of fine nights.

EDWARD C. PICKERING,
Director,

Harvard College Observatory Bulletin 544.
Cambridge, Mass., U. S. A.
March 14, 1914.

Overworking the Acid Fixer.—Many photographers who are using the acid fixing bath are running a serious risk of producing prints which will discolour in a short time, for the simple reason that they regard the solution as inexhaustible that is, as long as any solution remains. With plain hypo solution the discol-

ouration would have warned them that the bath had done its duty, and it would have been thrown away while still energetic, but with the acid hypo solution there seems to be an idea that while it is clear it is still usable. This false economy often follows the purchase of ready mixed fixing salts, the photographer expecting a shilling tin to do the work of a shillings worth of hyposulphite of soda. We have repeatedly pointed out that is easy to test the fixing powers of a bath for prints by immersing a strip of undeveloped negative plate in it and noting the time required to clear it. If ten minutes are required for this, the solution should be discarded and a fresh one made. The worst point about the matter is that prints fixed in a wornout bath appear all right at first, but in a few weeks they turn yellow and tend to sulphurise in the shadows. In the case of negatives fixed in such a bath a metallic lustre and a general muddiness are often apparent as soon as they are dry. Those who are taking up acid fixing may need to be told that with the same strength of hypo the action is appreciable slower than with the plain solution. (*British Journal of Photography*. Sept. 12, 1913.)

Actual Time of Signals from the U. S. Naval Observatory, February, 1914.

Day	Time of Signals Noon. h m s	Error.	Time of Signals 10:00 P.M. h m s	Error.	
1	12 0 0.19	+ .19	10 0 0.21	+.21	Sunday
2	12 0 0.26	+ .26	10 0 0.06	+.06	
3	12 0 1.09	+1.09	9 59 59.41	—.59	Accident to transmitting clock.
4	12 0 0.13	+ .13	10 0 0.01	+.01	
5	12 0 0.04	+ .04	10 0 0.05	+.05	
6	12 0 0.05	+ .05	10 0 0.08	+.08	
7	12 0 0.07	+ .07	10 0 0.09	+.09	
8	12 0 0.10	+ .10	10 0 0.14	+.14	Sunday
9	12 0 0.15	+ .15	10 0 0.04	+.04	
10	12 0 0.08	+ .08	10 0 0.09	+.09	
11	12 0 0.11	+ .11	10 0 0.14	+.14	
12	12 0 0.14	+ .14	10 0 0.00	.00	
13	12 0 0.02	+ .02	10 0 0.01	+.01	
14	12 0 0.01	+ .01	9 59 59.98	—.02	
15	12 0 0.01	+ .01	10 0 0.01	+.01	Sunday
16	12 59 59.99	— .01	10 0 0.00	.00	
17	12 0 0.01	+ .01	9 59 59.99	—.01	
18	11 59 59.97	— .03	9 59 59.97	—.03	
19	11 59 59.96	— .04	9 59 59.92	—.08	
20	11 59 59.95	— .05	9 59 59.94	—.06	
21	11 59 59.94	— .06	9 59 59.99	—.01	
22	12 0 0.01	+ .01	10 0 0.02	+.02	Sunday
23	12 0 0.01	+ .01	10 0 0.06	+.06	
24	12 0 0.05	+ .05	10 0 0.04	+.04	
25	12 0 0.08	+ .08	10 0 0.07	+.07	
26	12 0 0.05	+ .05	10 0 0.10	+.10	
27	12 0 0.01	+ .01	10 0 0.01	+.01	
28	12 0 0.01	+ .01	10 0 0.02	+.02	

Maximum error
February 3.....1.09

(+) slow
(—) fast

March 3, 1913.

J. A. HOOGEWERFF,
Captain U. S. Navy
Superintendent.

Milton's Astronomy, The Astronomy of 'Paradise Lost' by Thomas N. Orchard, M. D., Longman's Green and Co., New York, 1913. 288 pages, 8vo. Price $2.50, net.

A poet is allowed much license and one is not surprised in reading poetry to find many statements which do not accord closely with current knowledge of scientific truth. Mr. Orchard shows that Milton was remarkably well informed in regard to the astronomical theories of his day. Writing at a time when scientific thought was turning away from the ancient, Ptolemaic, conception of the universe to the modern, Copernican, system, he adopted for the purposes of his poem the former, while in a dialogue between certain of his characters he discusses the relative merits of the two systems in such a manner as to indicate that he really preferred the latter.

In the first chapter Mr. Orchard gives a brief historical sketch of astronomy, and in the latter part of the book describes in a very pleasing way several familiar celestial objects. Altogether the book is very readable and entertaining.

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